Engineers Australia
Engineering Heritage Victoria

Nomination

Engineering Heritage Australia, Heritage Recognition Program
For

Morell (Anderson Street) Bridge, Melbourne, Victoria

Earliest example of the Monier Concrete Arch Construction Method used in Victoria.

March 2015

Front Cover Photograph Caption

The Morell Bridge formerly known as Anderson Street Bridge was the first large structure built in Victoria using reinforced concrete.

The bridge was built over a newer section of the Yarra River originally on dry land, and after construction in 1899 the river was diverted to flow underneath. The Bridge has three equal spans of Monier arch while encompassing cast iron balustrades and ornamental Victorian lights.

Image: Owen Peake, December 2014

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1 Introduction[1]

Engineering Heritage Victoria (EHV) is a Victorian Special Interest Group of the Institution of Engineers Australia. Under its Heritage Recognition initiative a program exists which recognises structures built by General Sir John Monash and the Monash and Anderson partnership along with other associated companies.

Formally known as the Anderson Street Bridge, the Morell bridge was originally conceived to address local residents' desires for a bridge to allow vehicle movement and to improve the aesthetic quality of the banks along the Yarra River. Remarkably the bridge was constructed on dry land and once completed the river was diverted to flow underneath it. The main reason the river was diverted was to prevent and alleviate flooding upstream.

The Morell Bridge spans102 metres in length and is divided into three equal spans of Monier arch. The bridge has concrete abutments and piers at either end with the northern abutment built on piles through alluvial soils. The space between the arch and the roadway was filled and compacted with earth which was generally sourced from local areas. The bridge is in original condition and is fitted with ornamental cast iron balustrades and Victorian lights. The spandrel walls are decorated with ornamental decorations including large dragons which are etched out with cement mortar and painted grey. The gutters on the bridge are cobbled bluestone, with a single 5.7 metre wide bitumen lane running down the centre.

The Monier method of construction is basically a system which utilises the good compressive nature of concrete and the tensile strength of the iron rods as reinforcement. This system of reinforcing concrete was created and patented in 1867 by a French garden ware manufacturer named Joseph Monier. Monier was fed-up with his clay and wooden planter boxes breaking all the time, and therefore came up with the reinforced concrete system. He started making his planter boxes out of concrete using a grid like system of small iron bars as the reinforcement. The design was continually developed and ended up covering a range of things including arch bridges which was later patented in 1875.

Later in the 19th century the Monier system finally reached Australian shores. The system of reinforced concrete for arch bridges was embraced by the engineering and contracting firm Carter, Gummow & Co who had acquired the New South Wales and Victorian patent rights.

After a meeting with Frank Gummow of Carter, Gummow & Co, Joshua Anderson of the Monash and Anderson partnership negotiated an agreement for the firm to become the Victorian agents for the Monier patents. Furthermore Monash and Anderson also had involvement in many other bridges around the state; however the amount of involvement they had in the Morell Bridge is hard to decipher with the lack of evidence available.

Some argue that it was Monash and Anderson who came up with the design but evidence would suggest otherwise. Research indicated that Carlo Cantini, then Chief Engineer of the Public Works Department of Victoria, and W. J. Baltzer, Chief Designer of the Sydney firm of Carter, Gummow & Co is primarily responsible for the design as well as the construction.

The confusion started at the beginning when the Monash and Anderson partnership acted as local representatives on behalf of the Carter Gummow & Co firm right up until the contract was secured. The partnership originally helped negotiate with Cantini, conducted a site

[1] Alan Holgate Vicnet web site downloaded 10 December 2014.

investigation and acquired the necessary materials for the project to commence. However their involvement once the project was underway is still to some extent uncertain.

Also, when Monash and Anderson were submitting tenders for other projects they would occasionally include the Anderson Street Bridge as part of their past experiences. However this was considered common practice at the time as they had access to drawings, calculations and had clear admission to the site where they oversaw the initial stages of the project. Besides, they also included Princes Bridge, on which Monash had only worked as a junior site engineer and neither were meant to seem as they were taking full credit for the design and construction, but rather that they had been involved in the projects in some way or another.

Around 1910 a more efficient design was developed using reinforced “T” shaped concrete beams. Even today this method is still commonly being used and adopted for concrete bridge designs. The Monier design approach is therefore of historical importance as it represents an important step in the evolution of reinforced concrete bridge design.

Later in 1936 the bridge was renamed the Morell Bridge after Sir Stephen Morell who was a prominent Victorian businessman and Lord Mayor of Melbourne between the years of 1926 and 1928. Today the bridge is currently still in operation, used by mostly cyclists and pedestrian traffic, connecting the Royal Botanic Gardens to the Olympic Park precinct.

2 Heritage Award Nomination Letter

The Administrator
Engineering Heritage Australia
Engineers Australia
Engineering House
11 National Circuit
BARTON ACT 2600

Name of work: Morell Bridge

The above-mentioned work is nominated for an award under the Engineering Heritage Recognition Program.

Location, including addresses and map grid reference if a fixed work:

Grid reference:	37° 49' 39.53'' S
	144° 59' 05.93'' E
Altitude:	14 meters

Owner (name & address): Melbourne City Council, Customer Relations Team
City of Melbourne, GPO Box 1603, Melbourne VIC 3001

The owner has been advised of this nomination and a letter of agreement is attached at Appendix 9.

Access to site: Bridge is on a public path with close proximity to the ''T'' intersection of Anderson Street and Alexandra Avenue.

Nominating Body: Engineering Heritage Victoria

OWEN PEAKE
Chair, Engineering Heritage Victoria
Date: 31 March 2015

3 Heritage Assessment [2]

3.1 Item Name: Morell Bridge

Above: Construction of the Anderson Street (Morell) Bridge
Image: Melbourne University Archives

3.2 Other/Former Names: Anderson Street Bridge. See Appendix 8 for further explanation of the naming of the bridge.

3.3 Location: Bridge is on a public path with close proximity to the ''T'' intersection of Anderson Street and Alexandra Avenue.

3.4 Address: Same as above

3.5 Suburb/Nearest Town: South Yarra

3.6 State: Victoria

3.7 Local Govt. Area: Melbourne City Council

3.8 Owner: Melbourne City Council

3.9 Roadway Status: Local Road - Pedestrian/bicycles only bridge

3.10 Former Use: Road Bridge (All forms of road transport)

3.11 Designer: Carter Gummow & Co

3.12 Maker/Builder: Carter Gummow & Co

3.13 Year Started: 1898

[2] Alan Holgate Vicnet web site downloaded 5 December 2014

3.14 Year Completed: 1899

3.15 Physical Description[3]

The Morell Bridge has adopted the Monier arch design consisting of 3 equal spans. The spandrel walls making up the outer structure varies in thickness from approximately 600mm to 1200mm .These walls retain the fill material that are located within the structure which was typical for Monier arch bridges.

The southern abutment and the two piers are built directly on a solid siltstone base. The Northern abutment however is believed to be supported by 32 450-500mm diameter timber piles. These piles are 20 metres in length and were driven down to a solid siltstone bed. Furthermore the soil at the northern abutment is identified as Coode Island Silt. This material is rather unstable and does not provide an adequate amount of horizontal restraint for the abutment, hence the need for timber piles.[4]

3.15.1 Total Length: 102m

3.15.2 Total Width: 9.3m

3.15.3 Carriageway Width: 5.7m

3.15.4 Lateral reinforcement iron bars: Ø6mm, 75mm spacing

3.15.5 Arch Height: 3.7m

3.15.6 Arch Span: 29m

3.15.7 Arch Thickness: 410mm-510mm

3.15.8 Design Loading: 15.2 tonne steam roller plus 4.8 kPa distributed

Above: The Morell Bridge, Looking towards the Melbourne's CBD, on the eastern side of the northern abutment.

[3] International database for civil and structural engineering website downloaded 5 December 2014
[4] Srivelan Kathirgaman, Aurecon , Load Testing and Assessment of Morell Bridge across the Yarra River

3.16 Physical Condition[5]

The piers, abutments and arches of the bridge are in good condition considering their age. The only condition issues present are minor cracks on the soffit of the arches and a noticeable flattening of the northern most arch. This was most likely the result of uneven settlement right after its construction in 1899.

By 1993 there was also evidence of defects and problems which required attention. This resulted in the Melbourne City Council to commission Meinhardt Facade Technology to conduct a detailed structural assessment of the bridge.

The assessment revealed a number of concerns that needed to be addressed to ensure the structural integrity of the bridge. One of those concerns was in regards to concrete spalling at the soffit of the arches. It was also determined that this was the direct result of corroding reinforcement.

In addition there was also outward movement of the side walls. However one of the more concerning elements identified within the structural assessment was the flattening of the northern most arch. This was obvious with the minor deflection of the handrail illustrated in the image below.

Above: The Morell Bridge, Noticeable downwards deflection in the far arch left hand rail Image: Ryan Darcy December 2014.

Computations conducted on the bridge in 1993 revealed that modern day stresses were overloading the structure. The Melbourne City Council agreed with the findings and established load limits which prevented vehicle travel in 1998. This study also revealed that the cause of the northern abutment deflection was abutment related. Moreover this abutment is still currently being monitored.

Another obvious defect was the differential movement at the two longitudinal construction joints. These joints connect the nine meter wide bridge into three equal parallel sections. This caused a crack to appear and caused excessive leakage.

Right: Cracks in the joints on the soffit of the northern arch. Image Ryan Darcy December 2014.

[5] Ian Godson website downloaded 16 December 2014.

3.17 Modifications and Dates[6]

Early in 1943 it was evident that spalling of the structure had occurred, this prompted the spraying of mortar to cover the reinforcement and prevent it from further corrosion.

Also after the structural assessment in 1993 and after competitive tendering Remedial Engineering was awarded the contract and in 1994 the following works were preformed:

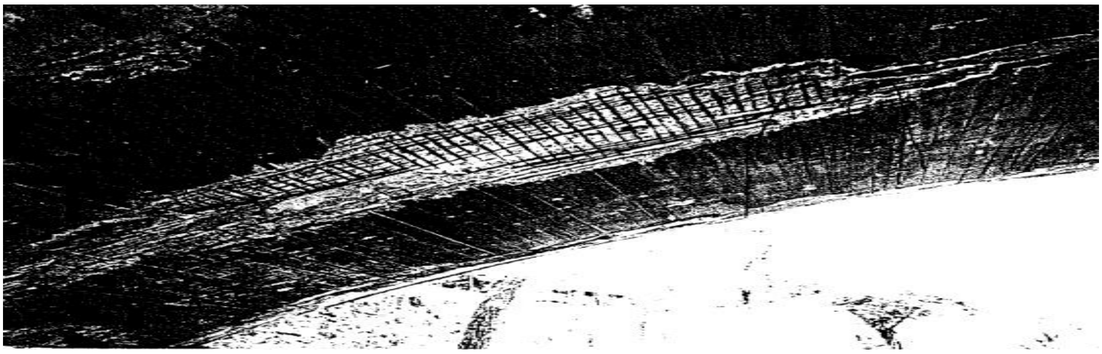
- Installation of a pipe drainage system to prevent further build-up of water within the fill material contained by the bridge.
- Installation of stainless steel dowels to prevent further outward movement of the side walls
- Creating flexible joints to accommodate the differential deflection at the longitudinal construction joints
- Coat the bridge soffit with a new thicker layer of mortar for further protection
- Recoat the decorative render to the side walls

After performing a structural modelling study it was concluded that the hand rails did not carry compressive loads. Furthermore it was not economically viable to raise the deflected handrails. However, it was established that re-profiling the sides to visually minimise the effects of the deflection would be a far more cost effective approach.

These restoration works took nine months and did not disturb the pedestrian and river traffic movement throughout the entire time due to suspended platforms being utilised.

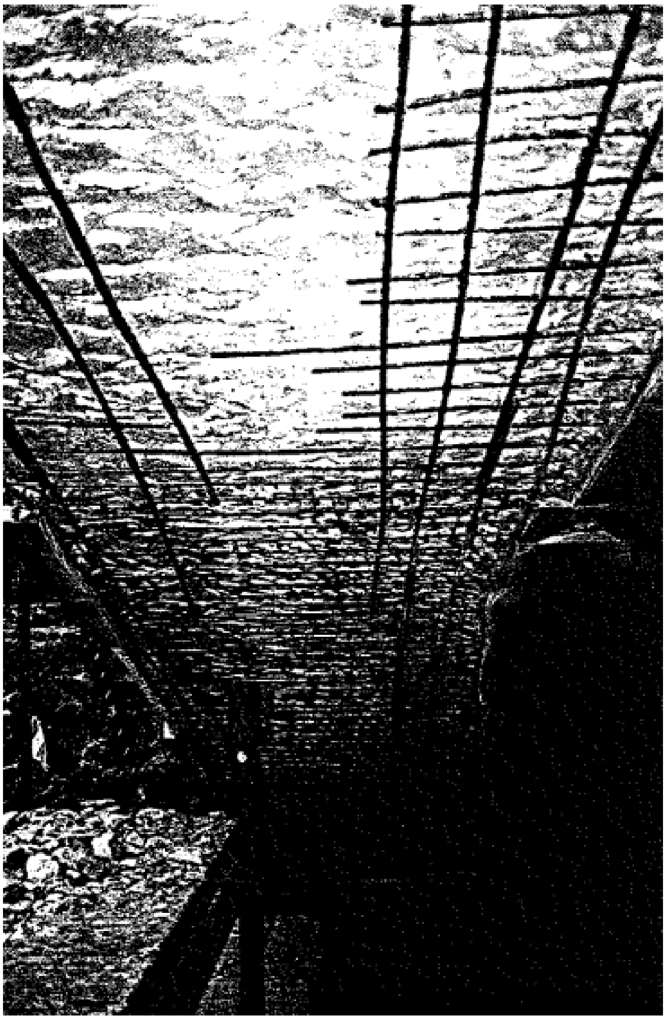
In addition there was also a cathodic protection system installed for a trial run and it was established that it could be used successfully to protect the reinforcement. By April 1994 there were four soil anodes embedded in the back fill of each span making 12 anodes altogether.

In March 1938 eight new Victorian style lights were given the green light to be installed with four being installed on each side. The public works committee of the Melbourne City Council planned the lights to fit the bridges current style and architecture. The total cost of these new lights including installation was around 450 pounds.

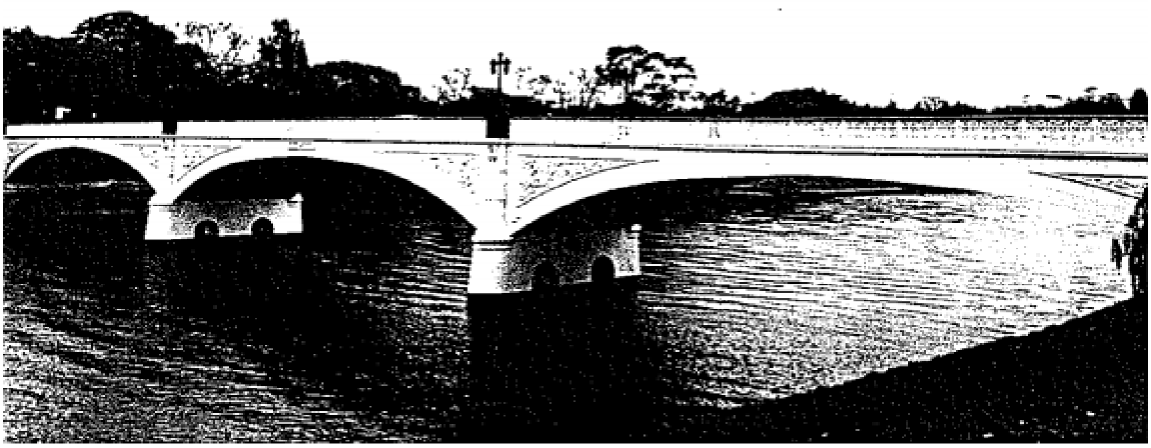


Above: Exposed reinforcement due to concrete spalling of the soffit
Image: Downloaded from the godson website.

[6] Ian Godson website downloaded 16 December 2014.



Above: Extent of concrete removal and reinforcement exposure of the Northern arch.
Image: Downloaded from the godson website.



Above: Morell Bridge after restoration works in 1994
Image: Downloaded from the godson website

3.18 Historic Individuals or Association[7]

See Appendix 2 for biographical information on:

1. John (later General Sir John) Monash
2. Joshua T N Anderson
3. Carlo Catani
4. W.J. Baltzer
5. Frank Moorhouse Gummow
6. Joseph Monier
7. Dr Alan Holgate

[7] Refer to Appendix 2

4 Assessment of Significance

4.1 Historical Significance:

The Morell Bridge has historical significance as it was the first structure built in Victoria using the Monier type of construction. After a number of bridges were constructed using the Monier approach the type of bridge designs changed.

Reinforced concrete girder bridges were adopted around 1910 and are actually still commonly used in bridge design. There have however been some recent modifications made to the design such as the prefabrication of bridge beams. The Monier bridge design and in particular the Morell Bridge have played an integral part in the evolution of bridge design, with an obvious transition from predominantly masonry or timber bridges to reinforced concrete bridges.

The earliest bridges using the Monier system also includes the Fyansford Bridge which came into service just before Wheelers Bridge in 1900.

- Fyansford Bridge was by and large solely designed and managed by Monash and Anderson and is located 4km west of Geelong.

- Wheelers Bridge was also designed and managed by Monash and Anderson and was completed in 1900; this bridge is located in Lawrence, Victoria.

Above: The Fyansford Bridge, noticeable downwards deflection in the far arch left hand rail
Image: Downloaded from the Alan Holgate website

Above: **Wheelers Bridge, Lawrence, 9 km north of Creswick, Victoria**
Image: Downloaded from the Alan Holgate website

4.2 History

4.2.1 Creation[8]

In the beginning the bridge originated through the desires of local residents who petitioned for a bridge which could carry vehicles from one side of the Yarra to the other. In order to alleviate flooding and to address these desires the bridge was eventually determined to be situated over a new conventional manmade section of the Yarra River.

In order to improve the construction conditions the bridge was originally constructed on dry land and the river was later diverted to flow underneath. The rivers original course was crossed by a foot bridge which was not designed for vehicle traffic.

Chief Engineer of the Public Works Department at the time Carlo Catani was eager to see a bridge connecting the inner parts of metropolitan Melbourne. His desires to revamp the banks of the Yarra and to connect the two suburbs together played an integral part in the bridges conception. It was later agreed that both the Melbourne City Council and the Public Works Department would share the initial costs as both would benefit from its construction.

During 1897 the inspector general of the Public Works Department, W. Davidson expressed ideas for a bridge consisting of three spans with brick abutments, cylinder piers and a timber truss. During October of that year Sydney firm, Carter Gummow & Co released drawings highlighting a 100 metre long bridge adopting a Monier arch design. This design included a typical pier system and two concrete abutments. A number of structural drawings illustrated computations for the bridge under various loading conditions, including the effect of a steam roller at various points along the length of its arch.

Midway through November, Davidson and Catani agreed that Gummow could have the project for 5000 pounds. However, Gummow initially estimated the construction to be around 5400 pounds, but he was willing to waiver the additional 400 pounds in order to maintain a solid relationship to attain future business. Catani along with other prominent engineers at the time were in favour of the Monier design and preferred it over timber trusses and iron girders.

In order to reach the most optimal design, the Minister of the Public Works department requested tenders for all types of bridge designs. This included designs using timber truss, iron girders and the Monier approach. The advertising for the tending stage began on 2 July 1898. A number of documents have revealed that the Monier plans for the then Anderson Street Bridge as well as the specifications were developed by the Public Works Department of Victoria. However, these were largely based on the preliminary drawings supplied by Carter Gummow & Co.

These newer plans incorporated the addition of 32 wooden piles and a grid of horizontal timber elements to stiffen up the north abutment block. These were included and seen as necessary elements in order to alleviate the problems with the alluvial soils located at the Northern end. Unlike the rock bed on the southern end, the northern end alluvial soils were unstable and subject to settlement. Therefore piles were seen necessary to transfer loadings from the bridge to the stable bed rock below.

In the beginning Anderson was keen to build the bridge under subcontract to Carter Gummow & Co, but it was finally agreed that the partnership would only act as their representatives and not have sole responsibility over the construction and design. This

[8] Alan Holgate Vicnet web site downloaded 18 December 2014

specific role would merely involve assisting Catani with negotiations, supplying local information, and providing office facilities for the Sydney based firm. However if certain circumstances arose Monash and Anderson would be ready to step in if need be.

During 1898 and after all tenders were submitted it was agreed that Carter Gummow & Co would build the bridge using the Monier system for 5700 pounds. The final design drawings were then signed on 10 October 1898 and the project finally commenced.

At the beginning of November, Gummow arrived in Melbourne to get his manager at the time, George Forrest up to speed and ready for the work to commence. Later that month the formal contract was signed and the first progress payment of 1200 pounds was made out to Carter Gummow & Co.

A document dated in mid February 1899 suggests this was when the first arch was completed, and on the 24th of that month the memorial stone was laid down by Mr Taverner, who was the Minister for the Public Works Department. Furthermore there is no evidence suggesting when the other two arches were formed, however some estimate this to have been completed by mid-April.

It is impossible to know exactly who first conceived the idea to use the Monier design of reinforcing concrete for the Morell Bridge. This could have come from any experienced engineer at the time however it is more likely that this idea came from the Public Works Department or an associated company.

Documents highlight that from September 1897 Monash was preoccupied with legal proceedings in Queensland and therefore could not have had a major input in the decision. The most likely individuals involved in this process were Anderson and Gummow. Even though Gummow was primarily based in Sydney he still had contact with a number of prominent engineers from his university days at Melbourne University. Gummow also had a brother living in Ballarat who was a prominent engineer who later helped Monash and Anderson push for a bridge contract there. Gummow therefore had a number of well-informed contacts which enabled him to keep up with the latest trends in the engineering world.

Anderson on the other hand played a very important role in proposing the Monier system for the Fyansford Bridge. Letters from Anderson suggest this could have been as early as September of 1897. It is therefore also possible that he could have had a similar role in the Morell Bridge project. However, there is little evidence to support this, while at the Fyansford Bridge there is an abundance of evidence. Therefore it is most likely that he had little to do with the end result. For that reason it is likely that Gummow was the one responsible for suggesting building the Morell Bridge using the Monier system.

Finally, after commencing with the project Anderson would have taken a backward step and taken on more of an advisory role within the project, with his main duties involving simply keeping Carter Gummow & Co in the loop.

4.2.2 Planning and Design[9]

Generally the design of a structure includes both the structure itself and the calculations behind the design. Typically an engineer's design is proven through the calculations carried out before the construction begins.

[9] Alan Holgate Vicnet web site downloaded 18 December 2014.

For the Morell Bridge the calculations for the initial design were shown on a single page accompanied by one design drawing illustrating the position of a number of point loads along the length of its arch. This document also indicates that it was produced in Carter Gummow & Co head office and was dated 28 October 1897.

The existence of this document suggests that someone within the Public Works Department and not Monash or Anderson completed the design. However it is possible that the arches were designed before it was known that the bridge would be constructed using the Monier method, as the technique for calculating Monier arches is the equivalent to that of stone arches.

Anderson himself was familiar with the design procedures for these arches and from September 1897 he was busy in the Fyansford Bridge project. In the beginning of October 1897 Anderson sent a detailed schematic including calculations surrounding the arches to Carter Gummow & Co. Additionally, Anderson also performed some of the calculations for later Monier type bridges around Victoria. However Anderson always had to work correspondingly with Carter Gummow & Co who held the patent rights. It is therefore quite possible that he himself could have made calculations and drawings for the Morell Bridge but somehow the documentation was lost. However, this scenario is unlikely and in one particular letter from Anderson to Gummow dated 22 June 1898, Anderson writes ‘’assuming you have perfect confidence in your design”, this statement alone suggests he had nothing to do with the overall design.

On the other hand Monash was also familiar with the design and quite possibly could have designed the Morell Bridge. However, the period when detailed design could have taken place Monash was preoccupied with legal duties in other states. This period ran from 30 September 1897, when Anderson held his first meeting with Gummow, to the 30 November of that year when Catani received Carter Gummow & Co's drawing. Throughout this period Monash was only ever in Melbourne for no more than nine days in total. Even once in Melbourne, Monash was heavily involved with his legal cases. It is therefore unlikely he could have played a significant part in the conception and design of the project and there is no evidence of this in any archives.

Catani is another person that may have designed the Morell Bridge. A major reason behind the rumour that Catani may lay claim to the design resulted from a drama surrounding a number of photographs published in 1899. The *Building Engineering and Mining Journal* published a picture of the then Anderson Street Bridge with the caption “Designed by the contractors Messrs Monash & Anderson". However after seeing the article Gummow was somewhat upset and swiftly wrote directly to the journal asking that they reprint the article and correct the error.

Gummow later wrote to Monash to explain the predicament and to ensure that the right person received due credit. Monash later replied to Gummow with a written apology. The journal accepted the error and reprinted the photograph with the caption "Designed by the Department of Public Works Victoria Messrs Carter & Gummow contractors". They also added to the photograph further with another caption saying ‘’the Victorian Public Works Department designed the work, which has been carried out under the supervision of Mr C Catani by Messrs Carter Gummow and Co”. The reprint clearly identified Monash and Anderson as only Victorian representatives for Carter Gummow & Co and nothing else.

After the article had been reprinted Gummow further expressed his concerns to Monash that he wished that the Public Works Department and Mr Catani would get due credit.

From the beginning, Catani was influential in rallying and pushing the Anderson Street Bridge idea through the initial conception phase of the project, and it is likely that this early contribution was what Gummow wished to be recognised.

It is therefore most likely that Baltzer and other junior engineers below him who came up with the design of the Morell Bridge. To further reinstate this theory in early June 1900 cracks were discovered within the bridge itself. Monash, Anderson and Catani all turned to Baltzer for reassurance that the bridge was still structurally sound. Later Baltzer visited the bridge and decided there were no fundamental flaws with the structure itself to which they all agreed and accepted.

4.2.3 Construction[10]

In determining the persons responsible for overseeing the construction it is a little easier to conclude than that of the bridges conception and design. The easiest person to rule out is Monash. Documentation shows that the construction of the bridge began in November 1898 and a load test took place on 20 July 1899. Between these two periods Monash was mainly in Perth attending other job ventures except for two brief visits to Melbourne.

The first visit was completed near the end of March 1899 and only lasted a little more than three and half weeks. The second trip was dedicated to attending a military camp at the beginning of July 1899. By this time the construction of the arches was well and truly underway, therefore Monash could not have made any major contribution to the management of the bridge's construction.

Like Monash, Anderson had a big involvement in early proceedings; he and Monash would most likely have been responsible for boring holes to determine the depth of rock at the north abutment among other things. However a number of letters from Anderson to Monash would suggest neither had primary involvement with the construction. Early on, it was hoped that Christian Christensen who was Monash and Anderson's foreman at the time would be subcontracted to build the centre of the arches. However this did not eventuate and he was not awarded the contract.

Anderson on the other hand did however have access to the site and it is known that his main duty in early operations was to assist Cantini in setting out the bridge so that the Public Works Department could start excavating the foundations. However, it is most likely that Anderson did not have a direct role in the day to day management of construction due to his various other work commitments. It is possible though that Anderson kept a close eye on things, advising Forrest only when needed. Though for this to be possible there should be evidence, which there is none.

It is therefore concluded that Monash and Anderson had little to no role in the construction process of the Morell Bridge, and this is highlighted by the fact that on a number of occasions Monash and Anderson had complained in a number of letters of the poor management of the bridge.

4.2.4 Conclusion[11]

In concluding all of the evidence it is most likely that as with all projects of today, a number of prominent people made important contributions. The original idea was pushed mainly by residents around the local area as well as politicians. Also we know today that it was the engineers at the Public Works Department who determined the spans. However, one of the

[10] Alan Holgate Vicnet web site downloaded 18 January 2014.
[11] Alan Holgate Vicnet web site downloaded 24 January 2014.

biggest questions though was who suggested the use of the Monier system? This idea could have come from any knowledgeable engineer at the time. However, it was most likely Anderson, Catani and Gummow who were primarily responsible for this and it was highly likely that Gummow was the major person behind pushing the Monier design.

Anderson's role in the project was to provide intelligence, liaise with key personal and to pressure political figures and the government. On the other hand Catani worked for the Public Works Department and was responsible for the bridges outcome. His role involved insuring the stability, function, and aesthetics and to ensure the cost of the construction was kept at a minimum. Inspector General, Davidson was mainly in a supporting role to Catani.

What most engineers would consider the design, the basic form of the piers and the profile of the arches were prepared by Baltzer himself or someone underneath his control.

Furthermore without any evidence to suggest otherwise it is highly unlikely that Monash and Anderson made any contributions to the computations regarding the bridges design. Monash and Anderson did however have the responsibility of ordering some materiel and took part in early site investigations. Though, once the initial stages of the project were finished it was the responsibility of the manager of Carter Gummow & Co, Forest to take care of daily operations management. However, Anderson may have kept an eye on proceedings and played a small advisory role, but Carter Gummow & Co was primarily responsible for this phase.

5 Interpretation Plan

5.1 Interpretation Strategy

The approach taken for the interpretation of the Engineering Heritage Works is laid out in the latest version of EHA's "Guide to the Engineering Heritage Recognition Program" [12]. The interpretation will first be made by marking the works with an appropriate level of heritage marker. A ceremony will then take place which will unveil the marker as well as an interpretation panel which summarises the heritage and the significance of the structure for the public to recognise.

The following plan provides a summary for the design of the proposed interpretation panel which includes the content, location and also the funding.

5.2 Event Date

The ceremony is planned for Saturday 12 September 2015 at 11:00 am. This date is to be confirmed with the owner, Melbourne City Council. The date is during the first round of the AFL Finals and there will likely be a game at the nearby MCG.

5.3 The Interpretation Panel

The location of the interpretation panel has not yet been agreed with the Melbourne City Council, owner of the land on which it is to be erected. However the south abutment is in near proximity to a ''T'' junction, with the two roads intersecting being Anderson Street and Alexandra Avenue. It will therefore be more appropriate and more likely that the interpretation panel be placed near the northern abutment which has far less traffic noise and pollution.

Ideally the interpretation panel will be situated 30-50 metres away allowing a clear view of the entire length of the bridge. Both the Western approach and Eastern approach are similar in nature; however there is more open space on the eastern side of the northern abutment, making this the more attractive position for the interpretation panel. The image below shows one possible location for the panel illustrated in the image by the red box. This location is safe and is clear of high traffic volumes, gives good views of the bridge with no obstacles blocking the view.

Furthermore this position should not create any unacceptable obstructions for regular council maintenance. Furthermore the panel will be mounted so that the bridge is in full view when the observer looks up from reading the interpretation panel. The marker will be mounted on the crossbar of the interpretation panel stand and measures will be taken to secure it against removal by vandals.

[12] The 2012 version is the latest available.

Left: Possible location of the interpretation panel
Image: Downloaded from Google Earth

The following information will be incorporated into the design of the Morell Bridge panel:

1) A title: **"Morell (Anderson Street) Bridge"**.
2) A subtitle: **"Earliest example of a Monier Bridge in Victoria"**.
3) Logos of Engineers Australia and City of Melbourne.
4) A small-scale representation of the EHA marker plate.
5) The date and other details of the marking ceremony.
6) A web site reference to the full nomination on the EHA web page.
7) A QR code to the above reference.
8) Text for main text panels should be 30-point Arial Bold.
9) Minimum text size should be 24-point Arial Bold.

10) The interpretation panel will technically be constructed and erected as follows:

    I. Size to be nominally 1200 mm wide by 600 mm high.

    II. The panel to be constructed of vitreous enamel-on-steel plate with flanges as per drawing at Appendix 8.

    III. The panel is to be mounted on a steel free-standing frame as per Appendix 8.

    IV. The EHA marker (Engineering Heritage Marker) is to be mounted below the interpretation panel as shown in Appendix 8.

5.4 Design Process for the Panel Content

This nomination will be reviewed throughout its development by the following groups:

1) The 10 members of the committee of Engineering Heritage Victoria
2) The Heritage Recognition Committee of Engineering Heritage Australia.

The design of the interpretation panel will be developed to the initial concept stage as part of the nomination writing process. It will then be further developed to a draft panel status by Richard Venus followed by review by the above reviewers plus the Heritage Recognition Committee and the site owner.

5.5 Funding

Funding for the interpretation panel is expected to be required as follows	Fund Source	Amount
Graphic Design including purchase of photographic rights	EHA National Budget	$500
Manufacture of panel by Glass Metal Industries	To be arranged	$1400
Manufacture of Steel Stand	To be arranged	$1000
Installation of panel stand and panel	To be arranged	$500
Supply from stock of marker by EHA	EHA National Budget	$200
TOTAL		**$3600**

5.6 Draft Interpretation themes for Interpretation Panels

In accordance with good interpretation practice, the content of the panels should be divided into three or four themes for ease of understanding by the public. The following have been assessed as possible themes/sub-themes for the interpretation panel:

Morell (Anderson Street) Bridge Panel:

a) Conception
b) The role of the engineers involved
c) Significance?
d) Why an arch bridge?
e) The development of Monier arch bridges

Total text should not exceed 500 words excluding headings.

5.7 Preliminary Text Blocks for Interpretation Panels

To be drafted

6 References

Godson I, Restoration of the Morell Bridge, Melbourne, viewed 9 December 2014, <http://www.godson.net.au/PDF/Morell%20Bridge%20Godson.pdf>.

Kathirgaman S, Load Testing and Assessment of Morell Bridge across the Yarra River, viewed 9 February 2015, <http://www.cmnzl.co.nz/assets/sm/3624/61/deAraugoi.pdf>.

Monash University, Sir John Monash, viewed 13 December 2014, <http://www.monash.edu.au/about/who/history/sir-john-monash.html>.

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Morell Bridge, viewed 9 December 2014, <http://structurae.net/structures/morell-bridge>.

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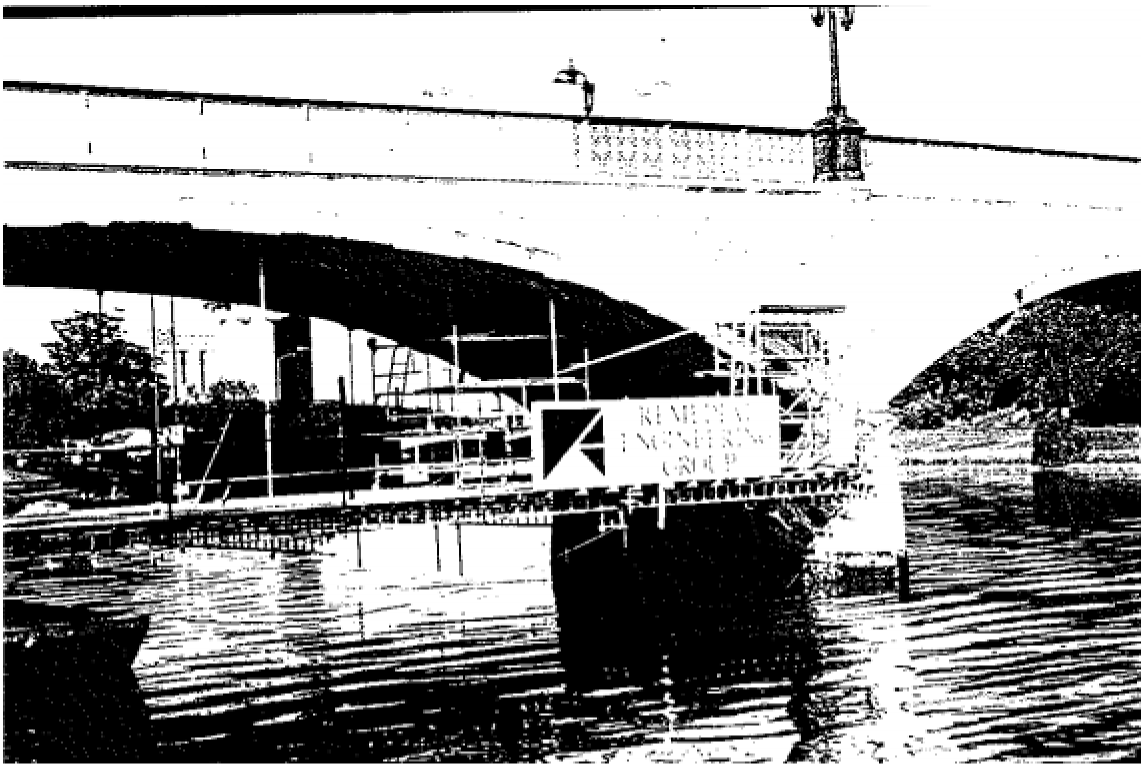
William Julius Baltzer, viewed 8 December 2014, <http://www.fairhall.id.au/resources/fame/baltzer.htm>.

Appendix 1
Images and Captions

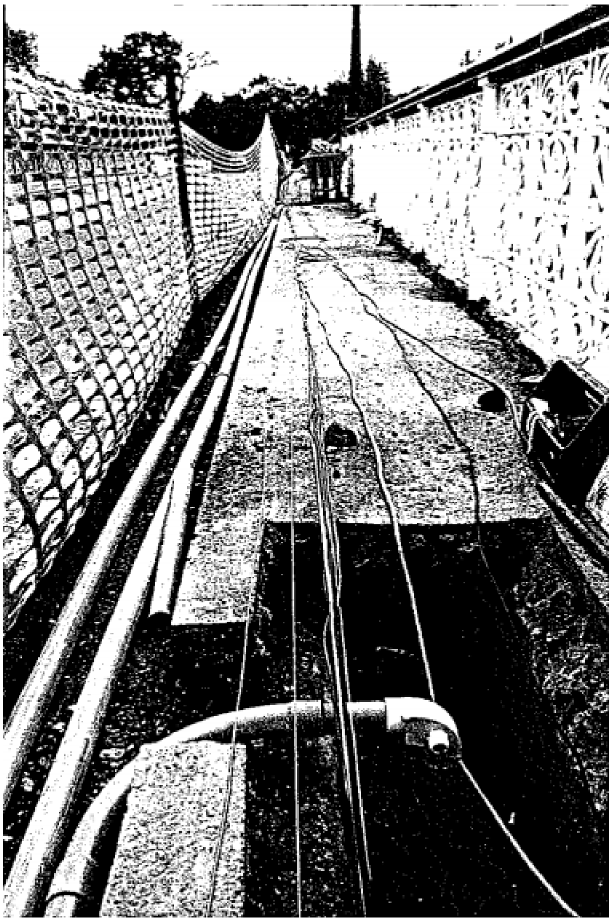
The Monash and Anderson Families 1897.

Above: Left to right (back): Joshua Anderson (seated); John Monash (standing); Victoria Monash (seated); Alan Holgate thinks that this is Anderson's brother Jack (standing); Anderson's son, Stewart, born May 1893 (seated); Ellen Anderson (seated); Seated in front left to right: Bertha Monash, born January 1892; The baby must be Alice Anderson, born June 1897; The girl on the right must be Frances Anderson, born November 1894.
Image: National Library of Australia

Above: The Morell Bridge before restoration in 1994
Image: Downloaded from the godson website



Above: Access platform for the restoration works in 1994
Image: Downloaded from the godson website



Above: Location of one of the soil anodes
Image: Downloaded from the godson website

Above: The load test of the Morell Bridge.
Image: Downloaded from the godson website

Note: Noticeable in the above photograph the Yarra River is yet to flow underneath the bridge.

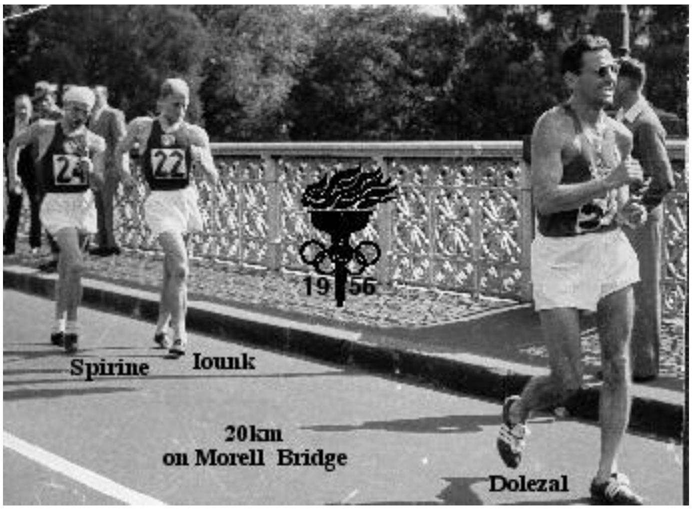
A1.2 Bridge Images

Above: Ornamental dragon design spandrel wall.
Image: Ryan Darcy December 2014

***Above:* Ornamental cast iron balustrade and handrails.**
Image: Ryan Darcy December 2014

Above: Overlooking the bridge from the eastern side of the northern abutment
Image: Ryan Darcy December 2014

Above: Ornamental Victorian Lights
Image: State Library of Victoria website



Above: 1956 Melbourne Olympics Race walk
Image: Downloaded from the Victorian Race walking club.

Appendix 2: Historic Individuals or Associations

A2.1 General Sir John Monash (1865–1931)[13] [14]

Engineer, Australian Military Commander and administrator

Sir John Monash was born on 27 June 1865 in Dudley Street, West Melbourne, Victoria, where he lived until the age of nine. He was born to Jewish parents, his father Louis Monash and his mother Bertha née Manasse.

Due to financial difficulties in 1874 his farther decided the family would have to move to the small town of Jerilderie located in New South Wales. Monash attended the public school there where they soon realised his great intelligence and the school later advised the Monash family to move back to Melbourne so that John would be able to reach his full potential.

After an education at Scotch College in 1881, were he was dux, he then began studying law, arts and engineering at the University of Melbourne at the young age of 16, however had to withdraw from studies due to financial troubles.

Before completing his degree in engineering Monash gained employment on the new Princess Bridge in 1885, and continued working with mentor contractor David Munro for the next two years. They designed and oversaw many bridges in and around the Footscray, Moonee Ponds and Coburg areas.

In 1888 Monash was chosen by Graham and Wadick to lead the design of the outer circle railway works linking Oakleigh to Fairfield via Camberwell. The project was completed by 1891 and Monash took a role on the Harbour trust which was an organisation that aimed to improve access for shipping vessels into the port of Melbourne, he remained in this position for two and a half years during the darkest times of the depression. During this time Monash also continued and furthered his studies part time.

Monash completed a surveyor’s course in August 1891 and later that year enrolled as a student of the Supreme Court. The following year he began studying again, studying the water supply engineer’s course and also completed his Bachelor of Arts.

By the time Monash was 30 he had achieved his Bachelor of Arts and a Masters in Science (Civil Engineering) and had qualified as a municipal surveyor, an engineer of water supply and a patent attorney. Later he would go on to become a Doctor of Law in 1922 and a Doctor of Engineering in 1921 at Melbourne University, a Doctor of Civil Laws at Oxford University in 1919 and a Doctor of Laws at Cambridge University.

During the month of June in 1894 Monash teamed up with friend Joshua T. Noble Anderson and started the firm of Monash and Anderson, which opened in Elizabeth Street, Melbourne.

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[13] General Sir John Monash biography written by Serle, G, 1986 *Monash, Sir John (1865–1931)*, web site downloaded 10 December 2014, <http://adb.anu.edu.au/biography/monash-sir-john-7618>.

[14] Monash University Archives web site downloaded 10 December 2014

Monash and Anderson became friends when Monash started tutoring him for the water supply engineer's exam in 1891. The firm concentrated primarily as civil, mining and mechanical engineering contractors.

Later, due to his legal background, Monash became in great demand as an expert in legal engineering works. Between 1897 and 1899 he spent a lot of time in Queensland, New South Wales and briefly in Western Australia working in the industry.

In September 1897 after a meeting with Frank Gummow of Carter Gummow & Co in Sydney, Anderson was able to reach an agreement making Monash and Anderson the Victorian agents for Monier reinforced concrete construction. Carter Gummow & Co held the Australian patent rights for the Monier reinforced concrete method. Serle (1982, p. 131).

This led to the pair having an involvement in many projects including the building of the Morell (Anderson Street) Bridge over the Yarra River in 1899, and becoming contractors for the Fyansford Monier Arch Bridge over the Barwon River, as well as other Victorian bridges. Monash and Anderson's were also involved in reinforced pipe manufacturing, with David Mitchell, and started the company Monier Pipe Co. Pty. Ltd. of Victoria in 1901.

In 1905 the Monash and Anderson partnership ceased and a new company was created known as the Reinforced Concrete & Monier Pipe Construction Co. Pty. Ltd. This company was created, to concentrate on the use of reinforced concrete in general building construction. The company undertook work on tanks, culverts, silos, country post offices, suburban banks and warehouses.

Furthermore Sir John Monash was a highly decorated military figure known for being an excellent leader and master tactician. Monash first started his military career at the young age of 19 and joined his University Company, D Company, 4th Battalion, and Victorian rifles.

Monash's leadership qualities and resourcefulness was soon realised which saw him rise through the ranks. During the First World War in 1914 he was the only brigade commander who originally landed at Gallipoli that was not killed or evacuated as wounded. In 1918 he was put in charge of the entire Australian Corps and later that year was knighted by King George V for his role in the battle of Hamel Hill.[15]

After the First World War, he returned to engineering and became Chairman of Victoria's new State Electricity Commission. Under his leadership the SEC became an important body in developing Victoria's brown coal reserves as an electricity source and, by 1930, extending the power grid across the whole of the State. In his last years, he supervised construction of Melbourne's Shrine of Remembrance and oversaw the public appeal for funds. He also rewrote the inscription planned for the west wall.

John Monash died in Melbourne on 8 October 1931 aged 66.

[15]Australian War Memorial web site downloaded 10 December 2014

A2.2 Joshua Thomas Noble Anderson (1865-1949) [16]

Prominent Engineer of the Monash and Anderson partnership

Anderson was born in Ireland in 1865 and graduated in engineering as well as arts. After a few years working as an engineer in Ireland, Anderson moved to Victoria in 1889. He later joined the Laanecoorie Weir project as an engineer. Afterwards Anderson took a position in mechanical engineering at the University of Melbourne, where he met and befriended John Monash.

The pair formed a business partnership in 1894 and in 1897, while Monash was in Western Australia, Anderson forged a link with the Sydney firm of Carter Gummow & Co and obtained through them sole rights to the Monier patent in Victoria. Anderson oversaw the initial negotiations, planning and design for the partnership's first two Monier arch bridges (Fyansford and Wheeler's); obtained many of their commissions and contracts; and consulted widely in the fields of mechanical engineering, water resources and mining.

By 1902 a downturn in the economy and two serious misfortunes had placed the partnership in severe financial trouble and its future was uncertain. Anderson elected to take up a salaried position in charge of design and construction of a new sewerage scheme for Dunedin, New Zealand. It is likely that the pair hoped to form a bridgehead there for the partnership and its related pipe factory, though nothing eventuated. Monash worked in Victoria at trading the firm out of debt and in 1905 it was agreed that the partnership be dissolved. Anderson relinquished his rights and was absolved from his share of the remaining debt. He travelled overseas for some time, then returned to Australia and spent the rest of his life in municipal engineering in Victoria, while retaining his independence as a consulting engineer".[17]

Joshua Anderson died on 18 October 1949 aged 84 years.

[16] Alan Holgate Vicnet web site downloaded 10 December 2014

[17] Anderson's life is summarised in a paper by Brian Lloyd. Stories of the bridge projects in which JTNA was concerned are available on the Alan Holgate web site via the following links: Morell Bridge; Fyansford Bridge; Wheeler's Bridge; Bendigo Arch Bridges; Kings Bridge, Bendigo; Barbers Creek Bridge and Woolert Bridge. There is much more in the archives at UMA and NLA on JTNA's consulting work, e.g. for the Mildura Irrigation Board and the Ballarat Woollen Mills.

A2.3 Carlo Catani (1852-1918)

Chief Engineer of the Public Works Department of Victoria (PWD)

Carlo Catani was a civil engineer that designed and oversaw the construction of many projects, including the Morell Bridge.

Carlo Catani was born on 22 April 1852 in Florence Italy. Mr Catani attended and attained an education as a civil engineer at the technical institute of Florence. In 1876 Catani arrived in Melbourne where he was employed as a draftsman by the Department of Land and Surveys. Then in 1880, Catani became a registered surveyor and two years later he and another colleague Ethore Chechhi joined the Public Works Department as engineering draftsmen. By 1886, they were both assistant engineers and later Catani was promoted to the head of his section.

Catani's other works included flood mitigation works on the Yarra River, planting elms, oaks and poplars along Alexandra Avenue, overseeing the completion of Alexandra Gardens and his last notable project was the reclamation of the St Kilda foreshore. Catani also designed gardens at the end of Fitzroy Street which were later named after him as was the Catani arch bridge on the St Kilda foreshore.

Today a bronze statue can be seen of Carlo Catani on the clock tower on the St Kilda esplanade. Carlo married Catherine Hanley in 1886 and had six children of which none of the children married.

A2.4 W. J. Baltzer (1859-1948)[18]

Chief Designer of the Sydney firm of Carter, Gummow and Co

William Julius Baltzer was born in Prussia, Germany in December 1859. Baltzer was a very influential person in the early days of the Monier design period and was a well-known consultant in the Monier method of reinforced concrete.

Baltzer even wrote about the Monier system in the engineering society of NSW journals, Volume 12, in a document dated 9 September 1897.

When W. J. Baltzer was unable to sway the minds of his colleges at the Public Works Department of Victoria in the Monier system, Frank Moorehouse Gummow and his partners took Baltzer on as their technical expert and joined him in taking out Australian patents under licence to Wayss in Germany.

[18] Fairhall web site downloaded 19 December 2014.

A2.5 Frank Moorhouse Gummow (1862-1946).[19]

Head of the Sydney firm, Carter Gummow & Co

Frank Moorhouse Gummow was born in 1862, he was the youngest of four sons, and his father was Benjamin Gummow. He studied engineering at Melbourne University where he achieved class two honours in February 1882. Later in 1885 Gummow married Annie Stratton and had a daughter Ida in Sydney in 1888.

Even though Gummow had technical knowledge, a comment in one of letters to Monash confirms he was more interested in the executive side of engineering. This suggests that it is likely that most of the technical content coming out of Carter Gummow & Co came from Baltzer, who was the Chief Engineer at the time.

The firm Carter Gummow & Co's first major projects using the Monier design were the aqueducts at Annandale (Sydney). The firm then progressed and went on to build many Monier arch bridges, and later service reservoirs, girder bridges and buildings in reinforced concrete. They also established a factory in Sydney making Monier pipes. After the death of Carter in 1898, the firm became ‘F. M. Gummow & Co', but then later Gummow partnered up again to form 'Gummow Forrest & Co'.

In September 1897 Gummow was at a conference about the Monier system, it was then Anderson, from the Monash and Anderson partnership who approached Gummow and persuaded him to accept Monash and Anderson as Carter Gummow & Co’s representatives in the Colony of Victoria, to which Gummow agreed. However, later the relationship between Gummow and Anderson took a turn for the worse which resulted in Monash heading the talks between the two groups.

Engineers assembled for the load test, 20 July 1899, Ignoring rows Frank Gummow is Second from the right, T.Short is second from the left, Cantini third from the left and Monash fourth from the right.
Detail. The original shows very faint features of the spandrels above the heads of the group.
***Image: National Library of Australia, Manuscripts Collection, MS1884 Sir John Monash*.**

[19] Alan Holgate Vicnet web site downloaded 19 December 2014.

A2.6 Joseph Monier (1823 - 1906) [20]

Creator of the Monier system of reinforced concrete

Joseph Monier was born in Saint Quentin la Poterie, France and became a renowned French gardener. Monier also became one of the most significant inventors of reinforced concrete.

As a gardener, Monier was not satisfied with the materials available for making flowerpots. Clay was easily broken and wood weathered badly and could be broken by the plant roots. Monier began making cement pots and tubs, but these were not stable enough.

In order to strengthen the cement containers, he experimented with embedded iron mesh. He was not the first to experiment with reinforced concrete, but he saw some of the possibilities in the technique, and promoted it extensively.

Monier exhibited his invention at the Paris Exposition of 1867. He obtained his first patent on July 16, 1867, on iron-reinforced troughs for horticulture. He continued to find new uses for the material, and obtained more patents — iron-reinforced cement pipes and basins (1868); iron reinforced cement panels for building façades (1869); bridges made of iron-reinforced cement (1873); reinforced concrete beams (1878). In 1875 the first iron-reinforced cement bridge ever built was constructed at the Castle of Chazelet. Monier was the designer.

The important point of Monier's idea was that it combined steel and concrete in such a way that the best qualities of each material were brought into play. Concrete is easily procured and shaped. It has considerable compressive or crushing strength, but is somewhat deficient in shearing strength, and distinctly weak in tensile or pulling strength. Steel, on the other hand, is easily procurable in simple forms such as long bars, and is extremely strong. But it is difficult and expensive to work up into customized forms. Concrete had been avoided for making beams, slabs and thin walls because its lack of tensile strength doomed it to fail in such circumstances. But if a concrete slab is reinforced with a network of small steel rods on its under-surface where the tensile stresses occur, its strength will be enormously increased.

Francois Hennebique saw Monier's reinforced concrete tubs and tanks at the Paris Exposition and began experimenting with ways to apply this new material to building construction. He set up his own firm the same year and in 1892 he patented a complete building system using the material.

In 1886 German engineer Gustav Adolf Wayss (1851–1917) bought Monier's patent and developed it further. He conducted further research in the use of reinforced concrete as a building material, and established the firm of Wayss & Freytag".

[20] Wikipedia, Joseph Monier, downloaded 12 December 2014.

A2.7 Dr Alan Holgate (1937 - Current) [21]

Senior Lecturer and Associate Professor in Department of Civil Engineering, 1965-1996.

The research of Dr Alan Holgate has been fundamental to this nomination. His material is collected together in a systematic manner on a Vicnet web site making it very accessible. All students of Monash's work are indebted to Alan for his body of work on Monash.
Alan Holgate was born at Chesterfield, Derbyshire, England in 1937. He now lives at Mooroolbark, in the outer eastern suburbs of Melbourne.

He was educated in various primary schools in Derbyshire and Devon then moved on to Newton Abbot Grammar School, studied civil engineering at University College, London, from 1955 to 1958 and obtained a BSc(Eng).

He carried out supervision of road maintenance and construction with the Department of Main Roads, New South Wales from 1958 to 1961 then worked as Office Engineer at Marples Ridgway & Partners, London from 1961 to 1962.

Returning to Australia he worked on hard rock tunnelling supervision for the Snowy Mountains Hydro-Electric Authority, Eucumbene, Australia from 1962 to 1963 then in power station design, Snowy Mountains Hydro-Electric Authority, Cooma from 1964 to 1965.

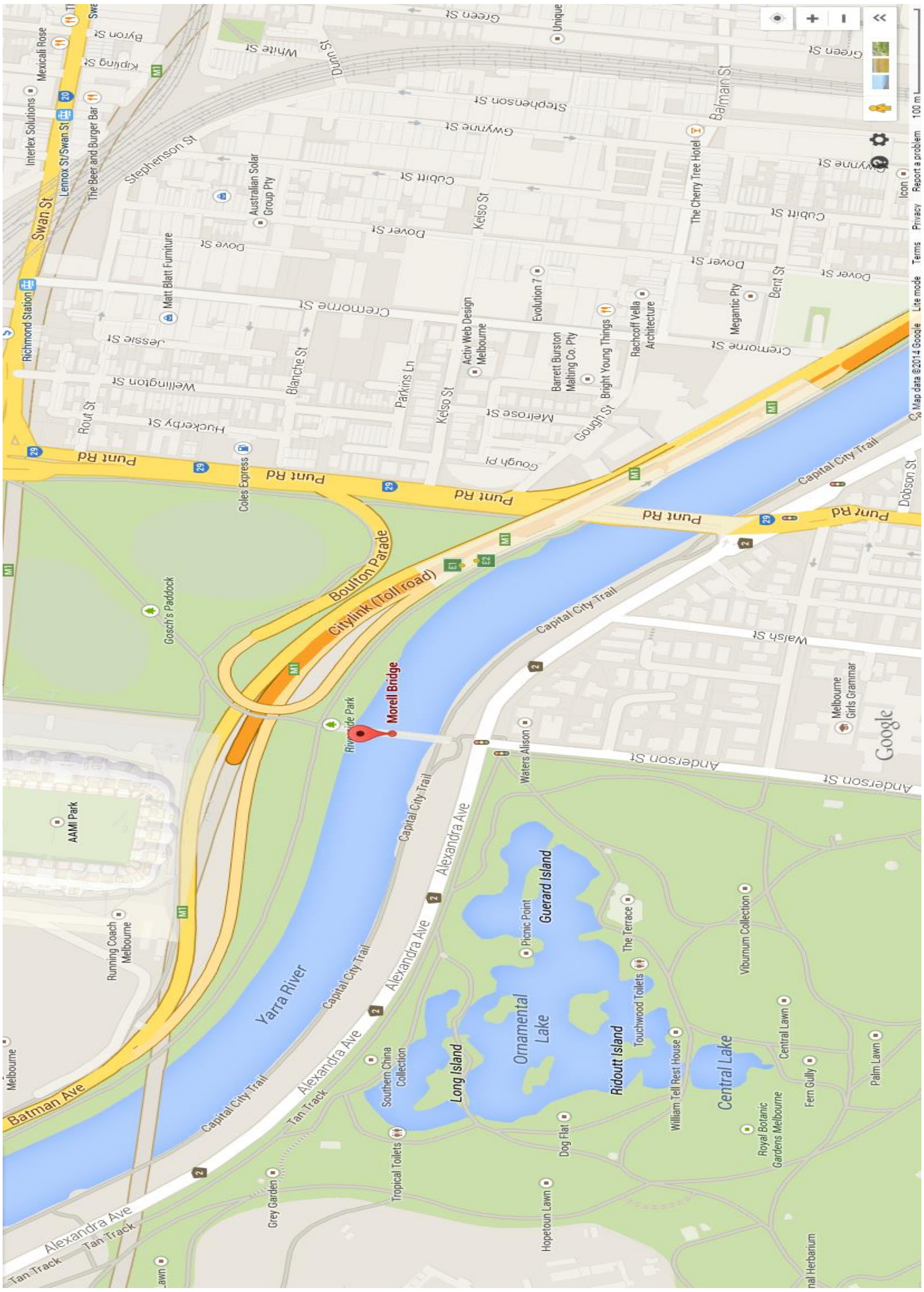
He then took up teaching and research in analysis and design of structures with the

Department of Civil Engineering, Monash University, Melbourne from 1966 to 1996. During this time he was a lecturer from 1967 to 1971, Senior Lecturer from 1972 to 1993 and Associate Professor from 1994 to 1996.

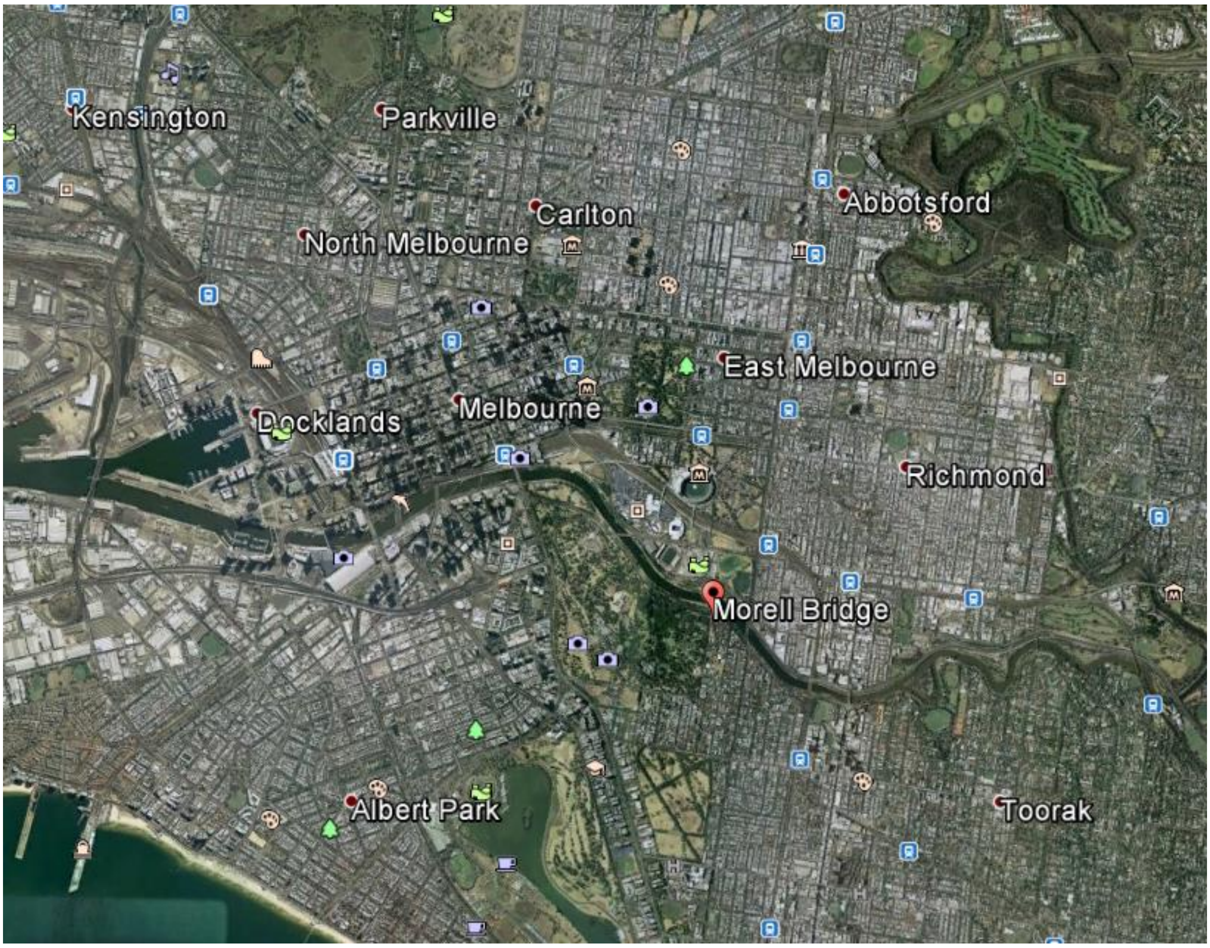
He obtained his Ph.D. at Monash University in 1996 and since retiring from Monash has been in Independent Scholar.

[21] Alan Holgate Vicnet web site downloaded 12 December 2014.

Appendix 3: Maps



A3.1 Location map indicating the Morell Bridge.
Image: Google Maps



A3.2 Location map indicating the Morell Bridge.
Image: Google Maps

Appendix 4: List of Monash and Anderson Monier Arch Bridges [22]

Bridge Name	*Date*	*Municipality (present)*	*Coordinates*
Anderson St."Morell."	1899	Melbourne.	-37.8275, 144.9850
Fyansford.	1900	Greater Geelong Golden Plains.	-38.1420, 144.3087
Wheeler's.	1900	Hepburn.	-37.3230, 143.8916
Oak St.	1901	Greater Bendigo.	
First King's.	1901	Greater Bendigo.	
Booth St.	1901	Greater Bendigo.	-36.769847, 144.261839
High St.	1901	Greater Bendigo.	-36.769628, 144.263867
Wade St.	1901	Greater Bendigo.	-36.77042, 144.26082
Scott's Creek Culvert.	1901	Moorabool.	
Second King's. (Weeroona Ave).	1902	Greater Bendigo.	-36.74364, 144.29165
Abbott St.	1902	Greater Bendigo.	-36.758347, 144.289917
Myrtle St.	1902	Greater Bendigo.	
Thistle St.	1902	Greater Bendigo.	-36.76837, 144.26710
Barber's Creek.	1901	Whittlesea.	-37.57440, 145.10448
Wollert.	1901	Whittlesea.	-37.59590, 145.05357
Coliban.	1902	Macedon Ranges.	-37.284840, 144.397248
Ford's Creek.	1903	Delatite.	

[22] Alan Holgate, list of Arch Bridges.

Ballan.	1905	Moorabool.	
Porepunkah.[23]	1913	Alpine.	-36.69700, 146.89393

[23] This bridge was constructed well after the Monash & Anderson partnership was dissolved in 1905.

Appendix 5: Time Line for John Monash [24]

1865	Birth - 27 June, at Dudley Street, West Melbourne
1874-75	Resided with family in Jerilderie, New South Wales
1877-81	Student at Scotch College
1882	Enrolled at University of Melbourne
1884	Joined University Company of the Victorian Rifles, appointed Colour-Sergeant in 1886
1884-87	Employed on construction of Princes Bridge and works in Melbourne for David Munro & Co.
1887	Commissioned in the Militia Garrison Artillery
1887	In charge of construction works for Outer Circle Railway, Melbourne
1891	Married Victoria Moss
1893	Master of Civil Engineering Birth of daughter Bertha
1892-94	Assistant Engineer and Chief Draftsman of Melbourne Harbour Trust. Qualified as Municipal Surveyor, Engineer for Water Supply and as Patent Agent
1894-1905	Private Practice (Monash and Anderson) as Consulting Engineer and Patent Attorney
1895	Awarded Bachelor of Arts and Bachelor of Laws
1897-99	Legal and engineering work in Queensland, New South Wales and Western Australia
1901	Formed Monier Pipe Company Pty. Ltd. (Monash, Anderson and Mitchell
1905	Formed Reinforced Concrete and Monier Pipe Construction Company Pty. Ltd. (Monash and Mitchell) in Melbourne
1907	Took command of Victorian Section of newly formed Army Intelligence Corps
1908	Promoted to Lieutenant-Colonel

[24] Monash University web site downloaded 11 December 2014

1912	President of Victorian Institution [25] of Engineers
1913	Appointed Colonel and commander of 13th Infantry Brigade in Victoria
1914	Leaves Australia in command of 4th Infantry Brigade, Australian Imperial Force (AIF)
1915	Promoted to Brigadier-General
1916	Promoted Major-General in command of new 3rd Division
1918	Knighted by King George V in the field
1918	Appointed Australian Corps Commander and promoted to Lieutenant General
1919	Returned to Australia
1920	Death of Victoria Monash
1920	Appointed General Manager of the State Electricity Commission of Victoria (SECV).
1921	Awarded Doctor of Engineering
1921	Appointed Chairman of the State Electricity Commission of Victoria
1921-31	Oversees design and construction of Shrine of Remembrance, Melbourne
1923	Chairman of Royal Commission into police strike
1923-31	Vice-Chancellor of the University of Melbourne
1929	Promoted to General
1929	Awarded Peter Nicol Russell Memorial Medal [26](Institution [27] of Engineers, Australia)
1930	Awarded Kernot Memorial Medal (University of Melbourne) for brown 1930 coal development
1931	Death - 8 October

[25] Institute corrected to Institution for clarity. This organisation pre-dated the Institution of Engineers Australia which was formed in 1919.

[26] Often referred to as the Peter Nicol Russell Medal.

[27] Institute corrected to Institution for clarity.

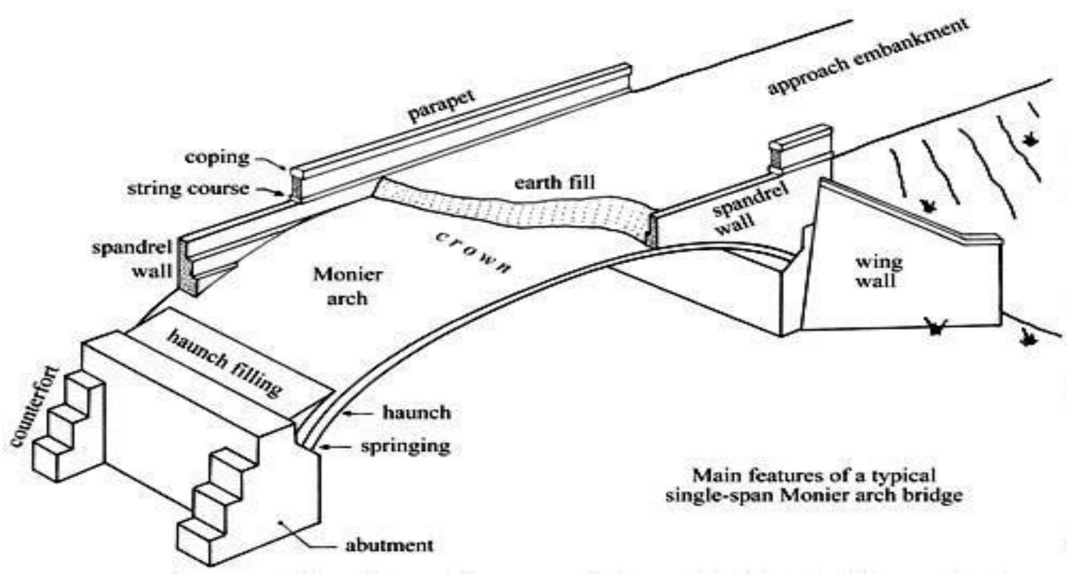
Appendix 6: Time Line of the Anderson Street (Morell) Bridge[28]:

28th October 1897 – First known drawing with results of computations.
June 1898 – Public Works Department adds timber piles to north abutment.
10th October 1898 – Contract and design drawings signed.
November 1898 – Start of construction.
20th July 1899 – Load Test conducted.
June 1900 – Concerns arise over cracks in north abutment and apparent sag in the northern span.
1943 – Spalling repaired with mortar gun
1994 – Restoration/stabilization works carried out and protection installed for reinforcement.
1998 – Bridge closed to vehicle traffic as part of the CityLink project

[28] International database for civil and structural engineering website downloaded 11 December 2014

Appendix 7: Basic calculations for Monier arch bridges as carried out by Monash & Anderson. [29]

This web page is devoted to the procedures used by Monash and Anderson, and their engineering assistants, to determine the profile for a Monier arch, and to calculate the resulting forces and stresses. It assumes that the reader has some basic knowledge of the mechanics of structures. It is restricted to the techniques used for M&A's early bridges, which were checked only for symmetrical uniformly distributed live load. The Upper Coliban Spillway Bridge is used as an example. Computations were sent to Sydney to be checked by W. J. Baltzer and F. M. Gummow. Baltzer had earlier used more complex procedures for the design and analysis of the Anderson Street (Morell) Bridge. After the collapse of the first King's Bridge at Bendigo, Monash obtained from him details of procedures for analysis for non-symmetrical and point loads, the most important 'point' loads being the axles of the steam rollers used in testing the bridges.

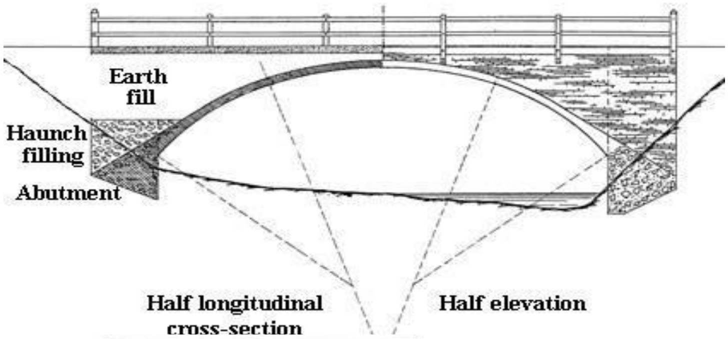


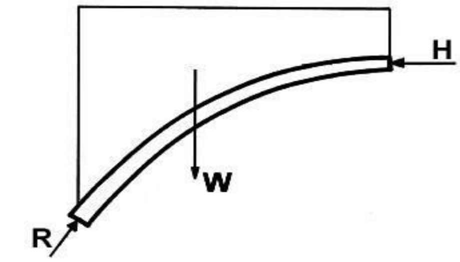
Main features of a typical single-span Monier arch bridge

[29] Alan Holgate Vicnet web site downloaded 10 December 2014.

The process used for design was a sort of 'form-finding'. At this early stage in the development of reinforced concrete, M&A and their advisors were unaware of any method for taking into account the presence of the reinforcement in an arch cross-section subjected to combined axial load and bending moment. The grids of small diameter bars provided in the Monier system were therefore ignored in analysis, and the aim was to shape the curve of the arch to avoid tensile stresses under normal loading conditions. This was achieved by ensuring that the centreline of the profile coincided with the line of thrust due to the self-weight of the arch, spandrel walls and filling. (Sometimes live load was included at this stage.)

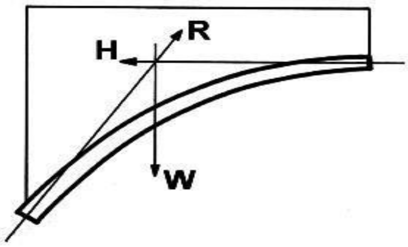
Checks were then made on varying live load conditions applied to the chosen form, to ensure that the thrust line did not deviate greatly from the centreline. Because the self-weight of the bridge was enormous in comparison with the live load, this was rarely a problem in theory. (In practice it turned out that the arch curve as built often deviated considerably from the theoretical curve owing to deflection and subsidence of falsework, and this was a much more significant cause of bending stress.)

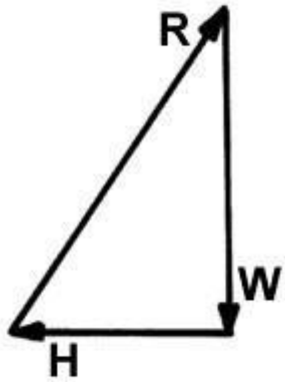




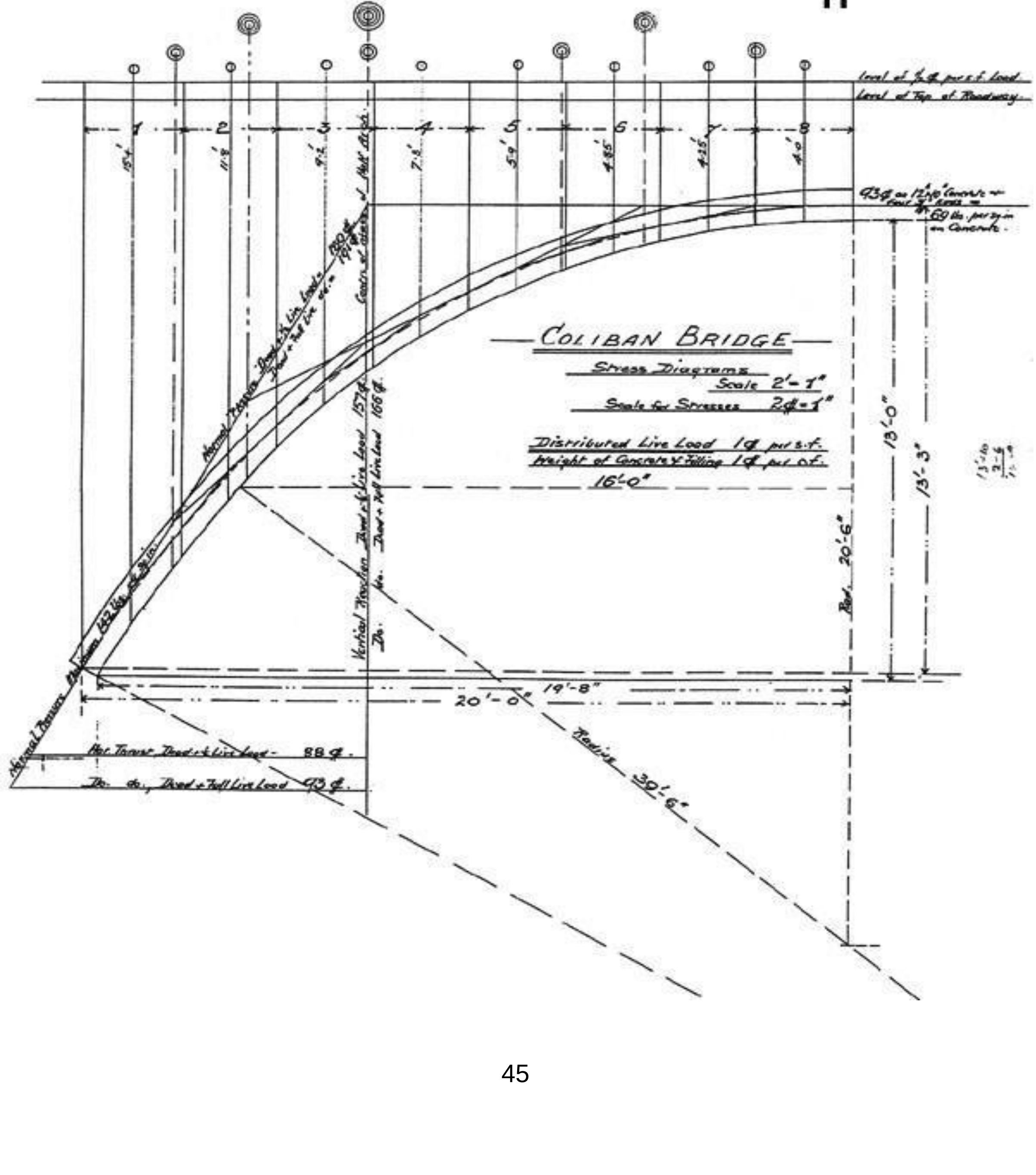
The left-hand side of the above drawing shows half of the longitudinal cross-section of a typical Monier arch bridge. The right hand side shows half of the side elevation. The arch profile is made up of three circular segments, as indicated by the radii. This is a simplified version of part of the working drawing for <u>Ford's Ck Bridge</u>, Mansfield.

The process of form-finding was iterative. All bridges were assumed symmetrical about the vertical centreline of the elevation, so that one half of the span could be treated as a 'free body' subjected to three forces: W, the total weight; R, the inclined reaction from the abutment; and H, the thrust in the crown exerted by the other half of the bridge. Because of the symmetry, and in the absence of a point load at the crown, H was horizontal. Assuming that the desired form had already been found, both H and R would pass through the centreline of the arch thickness, while W passed through the centroid of the half-arch. The lines of action of three forces which are in equilibrium intersect. Thus R passed through the intersection point of W and H.



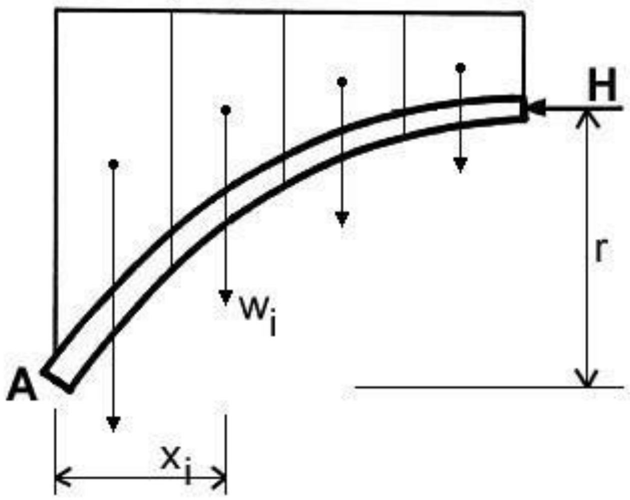


Hence a triangle of forces could be drawn. This gave the direction of R, while the magnitude of R and H could be determined by scaling from the known value of W. (H could also be obtained by taking moments about the abutment.)



This approach is evident in the drawing which J. S. Gregory produced for the Upper Coliban Spillway Bridge. (See below)

In the actual calculation process, the spandrels and fill above the half-arch were conceived as broken into segments by taking vertical slices across the width of the bridge. For clarity, only four are shown in the figure below, but normally eight were taken. It was customary to work with a strip of arch adjacent to the edge and one foot wide. The weight of the live load, when included, was indicated on the drawings as a surcharge comprised of an equally heavy volume of fill. In the Coliban calculations it appears that when the weight of a segment was calculated the specific weights of reinforced concrete, mass concrete, and earth fill were simply taken as a uniform 1 cwt force (112 lbf) per cubic foot (17.6 kN/m^3). When the arch was considered by itself (supporting its own weight during construction, or for an alternative scheme with timber superstructure) the specific weight of 'Monier' was taken as 150 lbf per cubic foot.



Taking moments about the springing point A:

H r = Sum (w_i x_i) thus

H = (Sum w_i x_i) / r

This approach is evident in the tabular calculations represented below. The same tables permitted the calculation of the total mass above the half-arch (Sum w_i) and the position of its centroid so that the location of the force W could be established.

In the table reproduced below, the effective half-span is taken as 20.08 feet and is split into eight vertical segments each of width K = 20.08 / 8 = 2.51 feet. The centre of gravity of each segment lies at the centroid of its area as seen in elevation. This is assumed to be midway between its vertical edges. The distances from the springing point to each centroid are expressed throughout in terms of K. For a one-foot wide slice in the direction of the span, the volume of each segment is one foot multiplied by its area as seen in elevation, i.e. 1 × K × (average depth). The average depths have been scaled from the drawing as

15.4, 11.8, etc. As the unit weight of all materials is taken as 1 cwt per cubic foot, the weight of a segment is simply 1 × K × (av. depth) × 1 = K × (av. depth). In column 2 the weight W of the one-foot wide slice of the half-span is summed as 62.62 K = 157.17 cwt. Its first moment about the abutment (Column 3) is 184.29 K^2 = 1161 foot-cwt. Hence the centroid lies 1161/157 or about 7.38 feet from the abutment. With these facts it is now possible to obtain the magnitudes of H and R and the direction of R.

Final set of calculations for Coliban Spillway Bridge "accepted design" with masonry spandrels.

by J. S. Gregory, 21 August 1901 (edited for this website.)

Dead load plus half live load. Span = 39'-4", Rise = 13'.

K = 20.08 / 8 = 2.51

Column 1	Column 2		Column 3		Column 4	Column 5
Lever arm from springing.	**Weight of segment.**		**Moment of weight about springing.**		**Segments grouped in twos.**	**Segments grouped in fours.**
K × 1/2 K × 3/2	**15.40K 11.80K**	**27.2**	**7.70 K^2 17.70 K^2**	**25.40**	**25.40 K^2 / 27.20 K = 2.34**	**73.95 K^2 /43.70K = 4.24**
K × 5/2 K × 7/2	**9.20 K 7.30 K**	**16.50**	**23.00 K^2 25.55 K^2**	**48.55**	**48.55 K^2 / 16.50 K = 7.38**	
K × 9/2 K × 11/2	**5.86 K 4.86 K**	**10.72**	**26.37 K^2 26.73 K^2**	**53.10**	**53.10 K^2 / 10.72 K = 12.43**	**110.34 K^2 /18.92K = 14.63**
K × 13/2 K × 15/2	**4.25 K 3.95 K**	**8.20**	**27.62 K^2 29.62 K^2**	**57.24**	**57.24 K^2 / 8.20 K = 17.52**	
Total	**62.62 K**		**184.29 K^2**			

Distance of centre of gravity of whole from abutment point = 184.29 K^2 / 62.62 K = 7.38'

Horizontal thrust = 184.29 × 6.3 / 13.25 = 87.6 cwt. Vertical Reaction = 157.17 cwt.

In the calculation for horizontal thrust 184.29 × 6.3 / 13.25, the 6.3 is K^2 and the 13.25 is 13'3", the rise from the abutment "hinge" to the centreline of the arch at the crown i.e. to the level of the horizontal thrust in the crown. The vertical reaction at the abutment must equal the total weight of the segments, 157.17.

To trace the full pressure curve within the arch the vertical slices are grouped first into four groups of two (Column 4). The positions of the centres of gravity are determined for each group. In Column 5 two groups of four segments are taken. This process can be traced through the system of symbols at the top of the drawing, consisting of small concentric circles:

Four small circles indicate the position of the total load W. Part way down its line of action, the intersecting lines of H and R can be seen.

Three small circles indicate the weight of the two groups of four segments. The points where their lines of action cut H and R are joined by a construction line.

This process is repeated until the level of the individual segment is reached, resulting in the thrust line, shown dashed. If the thrust curve differed significantly from the initially-assumed profile of the arch, the arch shape would be adjusted to fit the pressure curve, and the calculations repeated using revised segment weights. Generally, only two iterations were needed to achieve satisfactory agreement.

Appendix 8:
The Naming of Morell Bridge [30]

Some confusion surrounds the naming of Morrell Bridge. Questions have been asked such as:

- Was Anderson Street named after Joshua Anderson of the firm Monash & Anderson?
- Why was the name of the bridge changed to Morell Bridge in 1936?

Here are some facts and evidence to answer these questions.

1) The naming of Anderson Street

Anderson Street appears of the name of the street in question on a 1895 Melbourne & Metropolitan Board of Works map showing the proposed sewer layout for that part of South Yarra. Figure 1 shows the southern part of Anderson Street with the name "ANDERSON" clearly marked. This map predates the building of the bridge by 5 years so that it is clear that the street name existed well before the parties involved in the building of the bridge could have been identified.

Figure 1 shows Anderson Street running nearly north-south with two names attached. The name in capitals is from the original MMBW map. The second name in lower case is a modern artefact on this particular online copy of the map. The Royal Botanical Gardens are to the left of the image. The round object at the top of the image is 'Guilfoil's Volcano' which was a water supply reservoir at the highest point of the Botanical Gardens to provide water to the gardens. This feature still exists and has recently been restored.

[30] This appendix was written by Owen Peake of the Engineering Heritage Victoria Committee after work on the nomination by the Victoria University student had completed his work. This was in response to a question from the Heritage Recognition Committee.

Figure 2 – Guilfoyle's Volcano

Image: www.piecesofvictoria.com

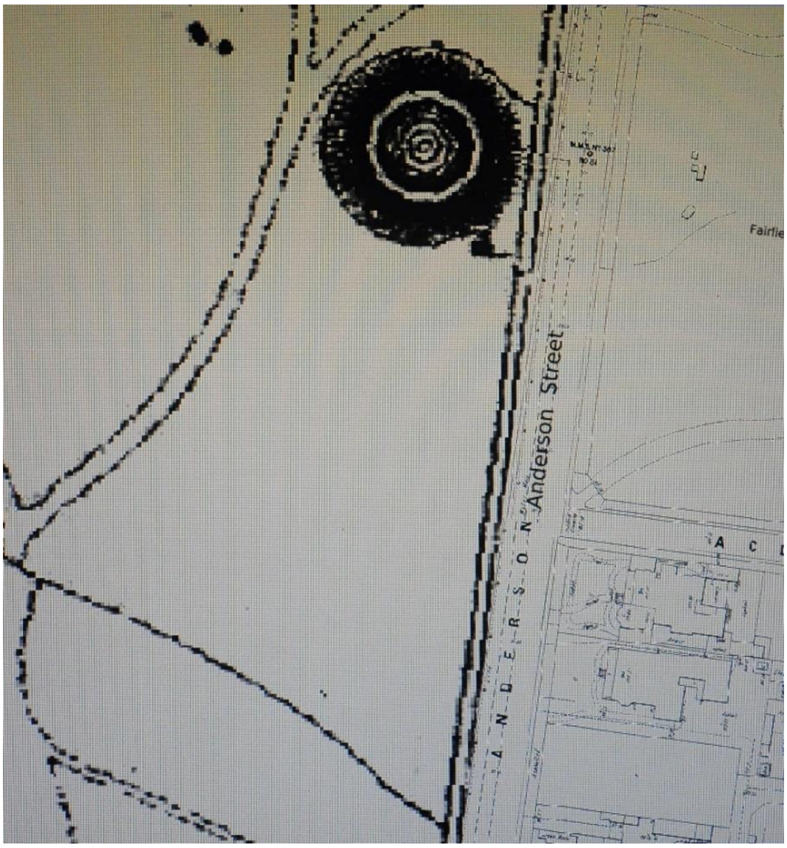


Figure 1 – Section of 1895 MMBW sewer map showing the name of Anderson Street.

Image: Photographed by Owen Peake from the web site of the City of Melbourne as the map was not able to be copies electronically.

2) Who was Anderson Street named after? [31]

No conclusive evidence has been found to link the naming of Anderson Street to any particular individual.

However it is most likely that the name was derived from Joseph Anderson, a military officer and member of the Colonial Victorian Upper House. He is known to have lived in South Yarra where Anderson Street is located.

Joseph Anderson was born in Scotland and served with the British Army for forty three years reaching the rank of Major in 1826. He served in the 78th, 24th, and 50th Regiments. His service included many overseas deployments. In 1834 the 50th Regiment was sent to Sydney and Anderson was appointed to the command of Norfolk Island where he served from 1834 to 1839. He moved to Melbourne in 1840 and purchased land in South Yarra overlooking the Botanical Gardens.

He retired from the army after a short deployment to India and became involved in Victorian politics. He served in the Victorian Legislative Council from 1852 to 1856.

He was regarded as a strict disciplinarian and in parliament advocated legislation to "prevent the influx of Chinese" [32]

3) Why was the name of the bridge changed? [33]

The name of the bridge was changed from Anderson Street to Morell Bridge in 1936.

The renaming commemorated Sir Stephen Morell, Load Mayor of Melbourne from 1926-1928. It should be remembered that the bridge was then and still is in the municipality of the City of Melbourne.

Morell was born in Carlton, Melbourne in 1869. He was primarily a businessman owning real estate in Melbourne including the Orient Hotel on the corner of Collins and Swanston Streets in Melbourne. He attended Scotch College.

He seems to have been a keen sportsman. He rowed for Scotch College and was the coach of the Scotch College rowing team at one time, retaining a keen interest in rowing throughout his life. He was a member of the Victorian champion team four and of the Victorian champion eight in 1986.

At the time of his death in 1944 he was President of the Victorian Rowing Association. He was also involved with the Metropolitan Amateur Football Association and was Vice-president of the Melbourne Cricket Club.

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[31] John V Barry, Australian Dictionary of Biography, Volume 1, Melbourne University Press, 1966.
[32] John V Barry, Australian Dictionary of Biography, Volume 1, Melbourne University Press, 1966, page 2, paragraph 1.
[33] David Dunstan, Australian Dictionary of Biography, Volume 10, Melbourne University Press, 1986.

4) Another interesting glimpse of Anderson Street

Figure 3 is taken from the same 1895 Melbourne & Metropolitan Board of Works map as Figure 1. This map shows the northern section of Anderson Street. The line of Anderson Street here is indistinct suggesting that it might still have been a 'goat track' in 1895 over the flats adjacent to the river. The street does however run more or less north south in the centre of the image.

The blue curve is the present Yarra River path and we know from elsewhere in this nomination that the Anderson Street bridge was built on dry ground and the river then diverted to go under the bridge. Figure 3 shows how this occurred. It should be noted that there was a foot bridge over the river in the vicinity. This was probably a wooden structure.

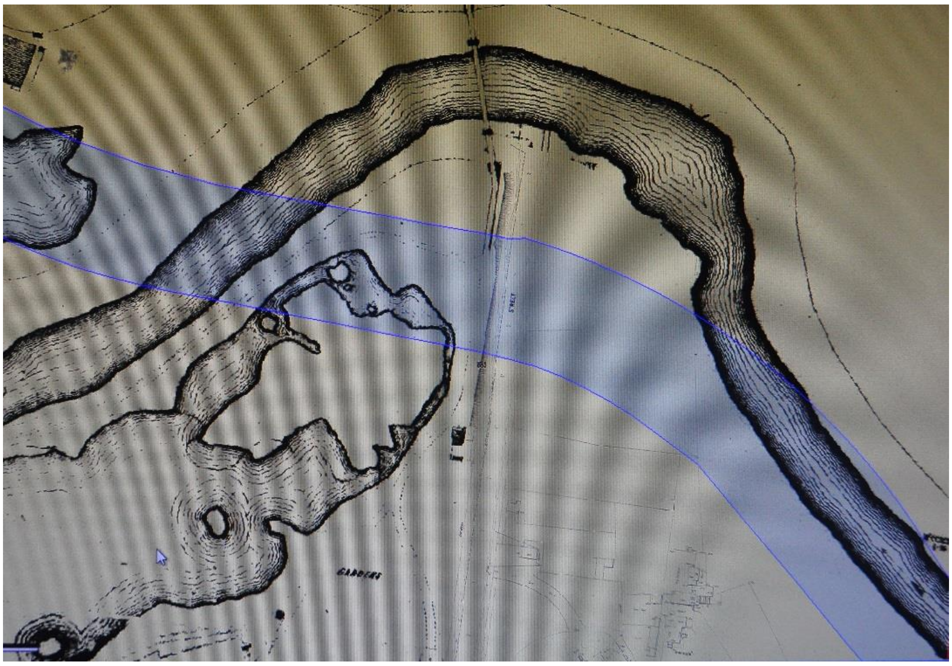
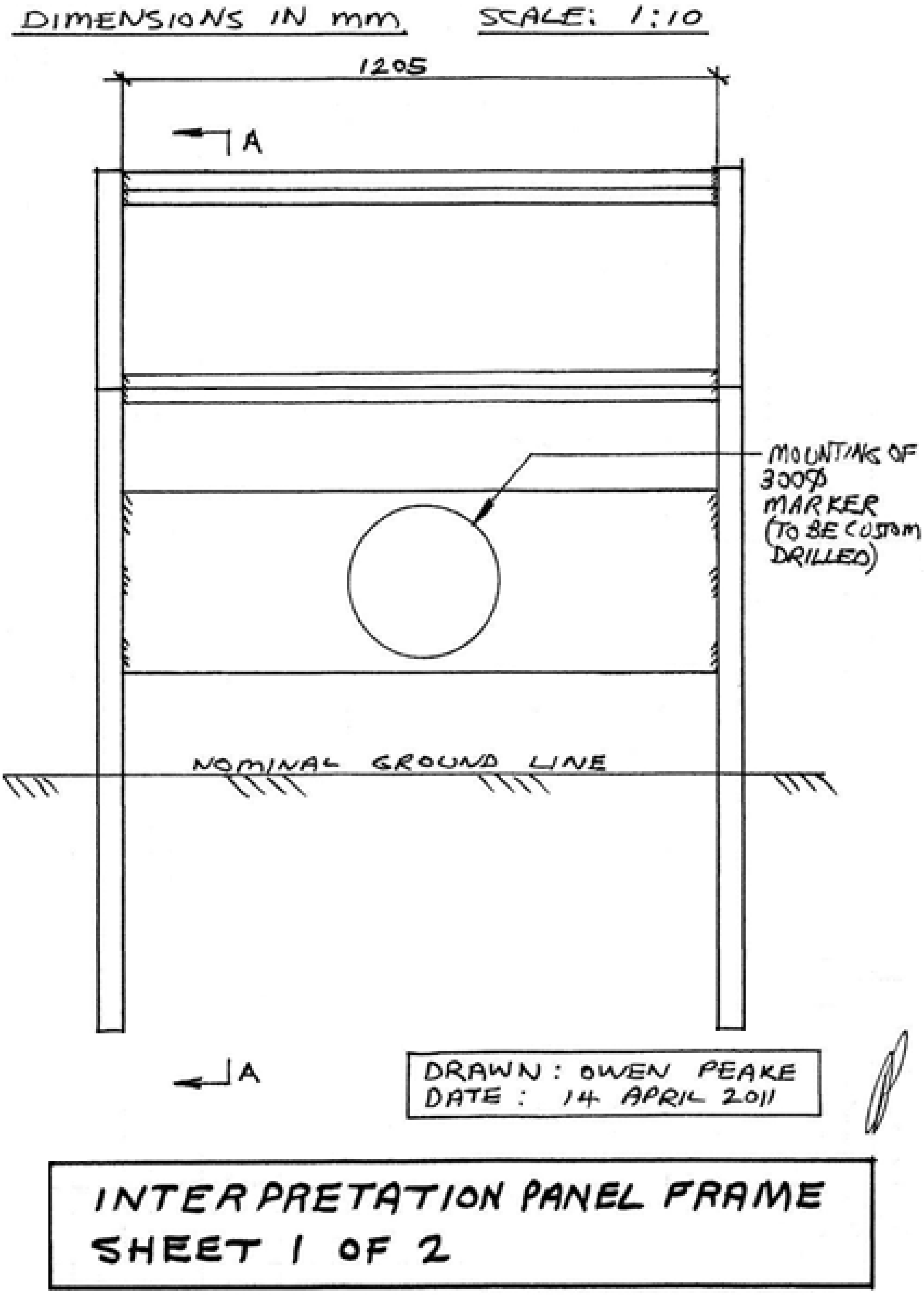


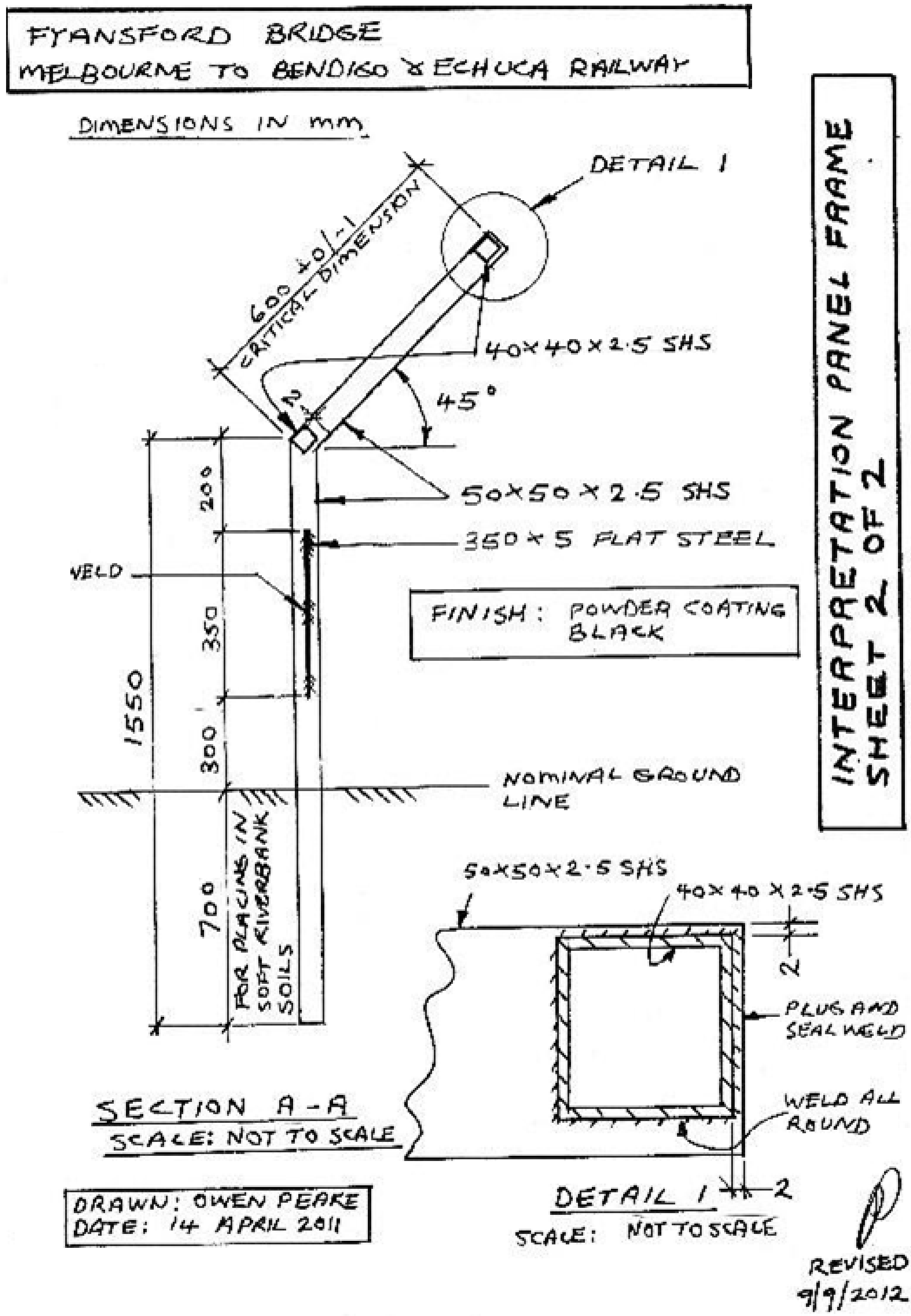
Figure 3 – Section of 1895 MMBW sewer map showing the Anderson Street Bridge site over the Yarra River at the centre of the image where the present river course (blue) intersects Anderson Street.

Image: Photographed by Owen Peake from the web site of the City of Melbourne as the map was not able to be copies electronically.

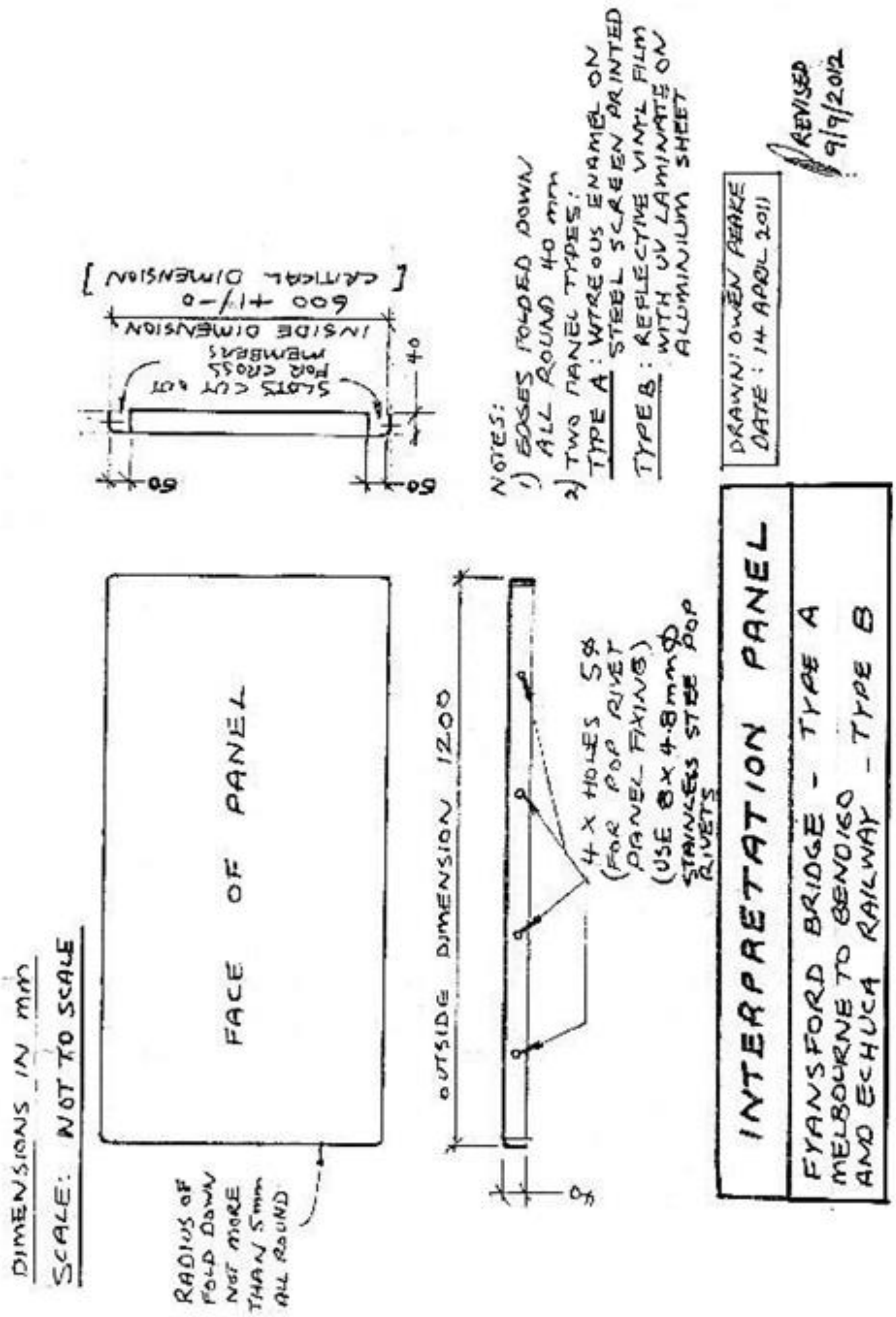
Appendix 9
Interpretation Panel and Mounting Frame Drawings



Drawing 1 – Interpretation Panel Mounting Frame Sheet 1 of 2
Image: Owen Peake



Drawing 2 – Interpretation Panel Mounting Frame Sheet 2 of 2
Image: Owen Peake



Drawing 3 – Interpretation Panel [34]
Image: Owen Peake

[34] Note that this panel is a Type A (vitreous enamel) in note 2 above.

Appendix 10: Letter of Approval from Owner

INSERT LETTER OF APPROVAL

Nomination prepared by:

Ryan Darcy

BE (Civil) Victoria University. Coursework completed 2014

Melbourne Victoria 3000

Phone: +61 459 397 777

Email: ryan.darcy@live.vu.edu.au

CHANGE CONTROL

VERSION 1	31/12/2014	11,262 WORDS	STARTED NOMINATION WITH BASIC REPORT FORMATTING AND TITLES, SUMMERISED RESEARCH AND INCLUDED IMAGES, BEGAN APPENDICES AND REFERENCES.
VERSION 2	16/01/2014	11,283 WORDS	AMENDED REPORT BASED ON SUGGESTIONS ON SPELLING, GRAMMAR AND MATERIAL AND RESOLVED FORMATTING ISSUES.
VERSION 3	29/01/2014	11,583 WORDS	READ OVER REPORT AND FIXED MINOR INCONSISTANCIES, CONTINUED TO FIX GRAMMAR, SPELLING AND SENTENCE STRUCTURE.
VERSION 4	5/02/2015	12,149 WORDS	ADDED TWO NEW SECTIONS TO THE REPORT, FIXED REPORT STRUCTURE AND ORDER, FORMATTED REPORT.
VERSION 5	7/02/2015	12,478 WORDS	ADDED NEW SECTION TO THE REPORT, REVISED REPORT AND AMENDED ISSUES.
VERSION 6	9/02/2015	12,562 WORDS	ADDED MORE CONTENT, REVISED REPORT STRUCTURE, GRAMMAR AND SPELLING.
VERSION 7	13/02/2015	12,924 WORDS	FURTHER CONTENT ADDED, CHECKED SPELLING AND GRAMMAR,
VERSION 8	20/02/2015	11,969 WORDS	FINALISING REPORT, ALPHABETICALLY REARRANGED REFERENCES, REMOVED SOME UNECESSARY WORDING.
VERSION 9	23/02/2015	11,735 WORDS	REVISED THE REPORT, CHECKED SPELLING AND GRAMMAR, REMOVED LAST APPENDIX
VERSION 10	27/02/2015	11,684 WORDS	FINAL REVISION, CHECKED SPELLING AND GRAMMAR, UPDATED TABLE OF CONTENTS, ADJUSTED MATERIAL TO PAGES
VERSION 11	1/03/2015	11,679 WORDS	REARRANGED REFERENCESD AND AUTHOR BLOCK AHEAD OF CHANGE CONTROL BLOCK (OP)
VERSION 12	18/04/2015	11,518 WORDS	Added date of 12 September for ceremony (OP).
VERSION 13	22/06/2015	12,687 WORDS	Added Appendix 8, minor editing of clause 4.2.2, moved References to before Appendices.
VERSION 14	23/06/2015	12,576 WORDS	Converted Table of Contents to manual entry to manage errors.
VERSION 15	22/08/2015	12,585 WORDS	Corrected ‘formerly’ p2 caption.

OUTSTANDING ITEMS

- **Ceremony date (page 20) to be confirmed.**
- **Draft text blocks for panel to be designed (page 22).**
- **Appendix 9 – Approval letter from Owner to be added (page 52).**